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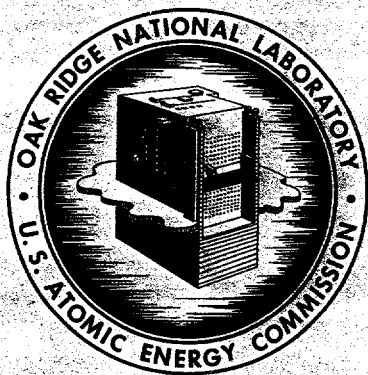
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UC-41 - Health and Safety

HEALTH PHYSICS AND SAFETY

ANNUAL REPORT FOR 1966



OAK RIDGE NATIONAL LABORATORY

operated by

UNION CARBIDE CORPORATION

for the

U.S. ATOMIC ENERGY COMMISSION

548

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HEALTH PHYSICS DIVISION

HEALTH PHYSICS AND SAFETY ANNUAL REPORT FOR 1966

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AUGUST 1967

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee
operated by
UNION CARBIDE CORPORATION
for the
U. S. ATOMIC ENERGY COMMISSION

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3.0 ACKNOWLEDGMENTS

The data for this report were contributed by: H. H. Abee, Section Chief of the Environs Radiation Monitoring Section; R. L. Clark, Section Chief of the Health Physics and Safety Surveys Section; E. D. Gupton, Section Chief of Applied Radiation Dosimetry Section; and A. D. Warden, Associate Department Head of Health Physics and Safety. Section 9.5, Whole Body Counter, was contributed by B. R. Fish, Section Chief of the Health Physics Technology Section.

4.0 SUMMARY

The gaseous and liquid waste releases from the Laboratory were such that the concentration of radioactive materials in the environs was well below the maximum levels recommended by the NCRP and FRC. The average concentration of radioactive materials in the atmosphere at the X-10 site was less than one percent of the maximum permissible for persons residing in the neighborhood of an atomic energy installation, and the concentration was, as expected, even less at the perimeter of the controlled area. The calculated average concentration of radioactive materials in the Clinch River at the point of entry of White Oak Creek into the River was less than two percent of the maximum permissible for persons residing in the neighborhood of an atomic energy installation.

No employee received an external or internal radiation dose which exceeded the maximum permissible levels recommended by the FRC. The highest whole body dose equivalent received by an employee was about 4.9 rem or 40 percent of the maximum permissible annual dose. No employee has a cumulative whole body dose which exceeds the recommended maximum permissible dose as based on the age proration formula $5(N-18)$. There were two cases of internal exposure where the deposition of radioactive materials within the body was estimated to have averaged greater than one-half of a maximum permissible body burden. Both of these cases involved inhalation exposures to ^3H and the resulting estimate doses to the whole body were 10.2 rems and 4.2 rems for the calendar year.

During 1966, there were 22 unusual occurrences recorded, which is the lowest number recorded since the present system of reporting unusual occurrences was established in 1960. The 22 occurrences is a decrease of 46 percent over the 41 reported for 1965.

The Laboratory reported 4 disabling injuries during 1965, which was a frequency rate of 0.51. The total number for the previous five years (1961-1965) was 56, or an average frequency rate of 1.5.

5.0 ENVIRONS MONITORING

The Health Physics Division monitors for airborne radioactivity in the East Tennessee area by the use of three separate monitoring networks. The local air monitoring (LAM) network consists of twenty-two stations which are positioned in relation to ORNL operational activities (Figures 1 and 2); the perimeter air monitoring (PAM) network consists of nine stations which are located on the perimeter of the AEC controlled area (Figure 3); and the remote air monitoring (RAM) network consists of eight stations which are located outside the AEC controlled area at distances of from 12 to 75 miles from ORNL (Figure 4). The monitoring networks provide for the collection of (1) airborne radioactivity by air filtration techniques, (2) radio-particulate fallout material by impingement on gummed paper trays, and (3) rain water for measurement of fallout occurring as rainout. The filter data are representative of radioparticulate matter which might be considered respirable; the gummed paper data are representative of radioparticulate fallout; and the rain water data provide information on the soluble and insoluble fractions of the radioactive content of fallout material.¹

Low level radioactive liquid wastes originating from ORNL operations are discharged, after preliminary treatment, to White Oak Creek, which is a small tributary of the Clinch River. Liquid waste releases are controlled so that the resulting average radioactive concentrations in the Clinch River are well below the maximum permissible concentrations established for populations in the neighborhood of an atomic energy installation as recommended by the National Committee on Radiation Protection (NCRP) and the Federal Radiation Council (FRC).

The radioactive content of the White Oak Creek discharge is determined at White Oak Dam (Figure 5) which is the last control point along the stream prior to entry of White Oak Creek waters into Clinch River waters. Water samples are collected also at a number of locations along the Clinch River, beginning at a point above the entry of wastes into the river via White Oak Creek and ending at Center's Ferry (near Kingston, Tennessee) about 16 miles downstream from the confluence of White Oak Creek and the Clinch River. Water samples are analyzed for gross radioactivity and for certain specified long-lived radionuclides. A weighted average, $(MPC)_w$, for the mixture of radionuclides is calculated on the basis of the isotopic distribution in the water.

Samples of ORNL potable water are collected daily, composited and stored. At the end of each quarter these composites are analyzed radiochemically for ^{90}Sr content and are assayed for long-lived gamma emitting radionuclides by gamma spectrometry.

¹A detailed discussion concerning techniques used in processing air and water samples for environmental monitoring purposes is given in ORNL-2601, "Radioactive Waste Management at Oak Ridge National Laboratory".

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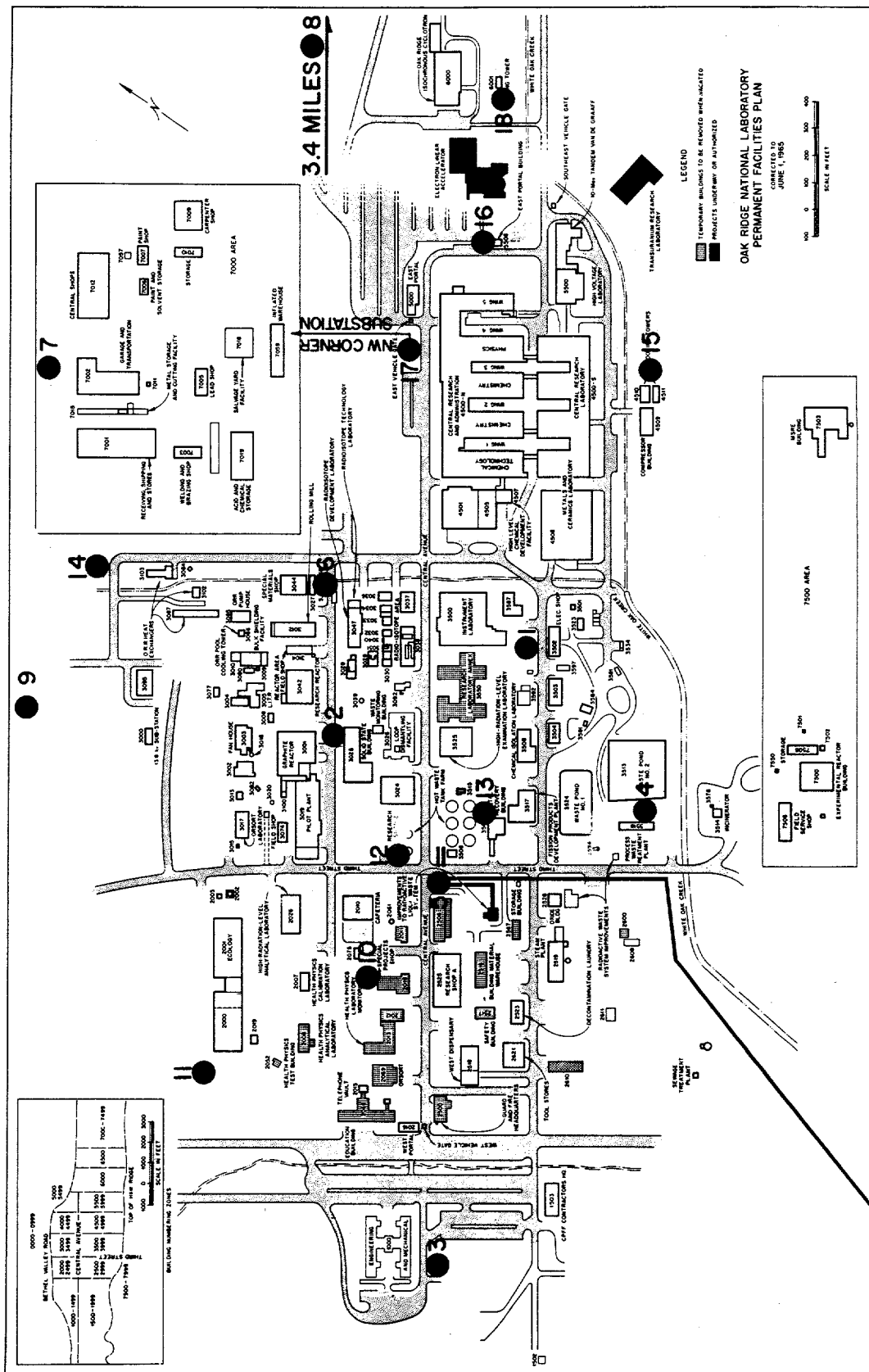


Fig. 1 Map of X-10 Area Showing the Approximate Location of 18 to 22 of the Local Monitoring Stations Constituting the IAM Network.



Fig. 2 Map of Laboratory Area Showing the Approximate Location of 4 of the 22 Local Monitoring Stations Constituting the LAM Network.

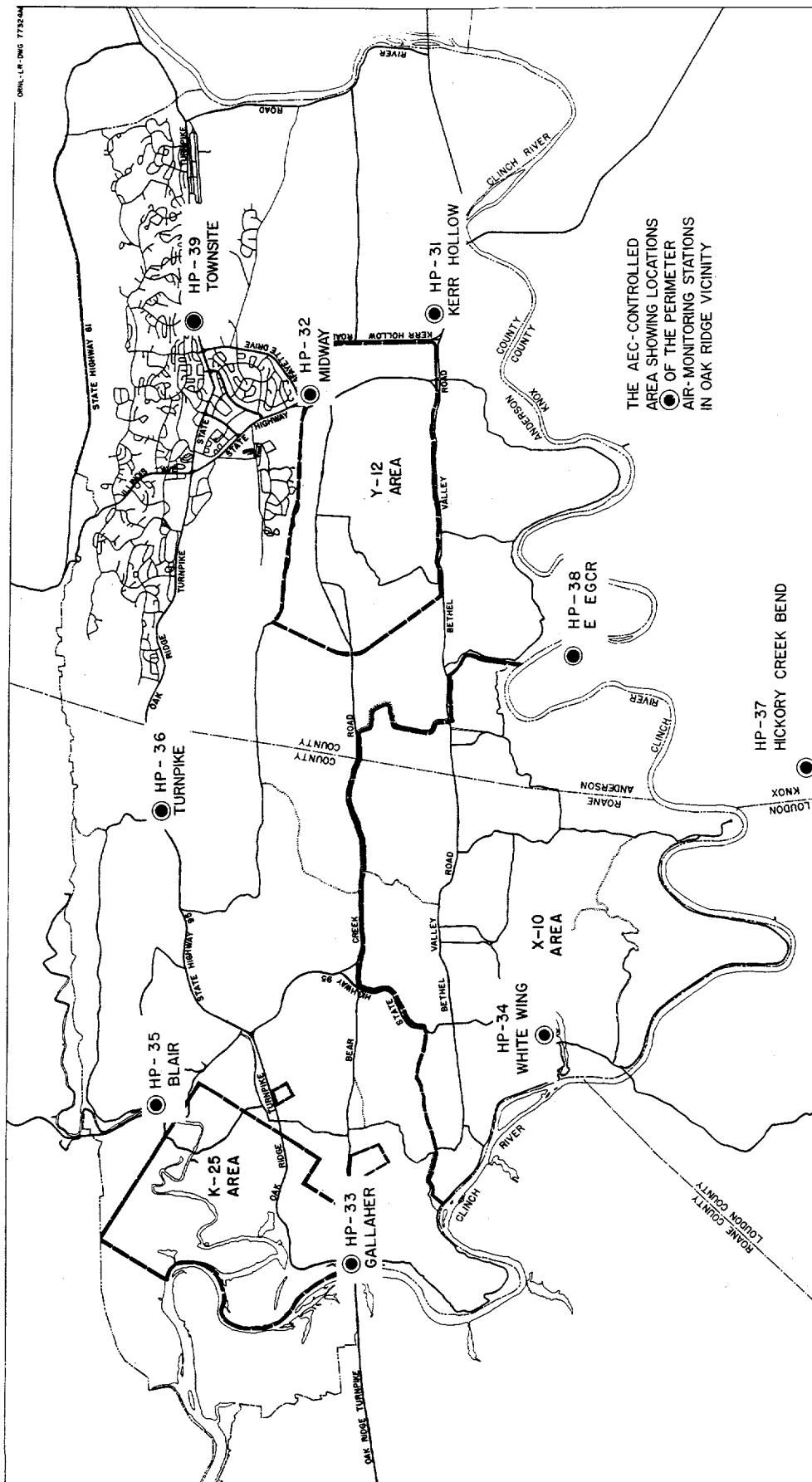


Fig. 3 Map of the AEC Controlled Area and Vicinity Showing the Approximate Location of the Perimeter Air Monitoring Stations Constituting the PAM Network.

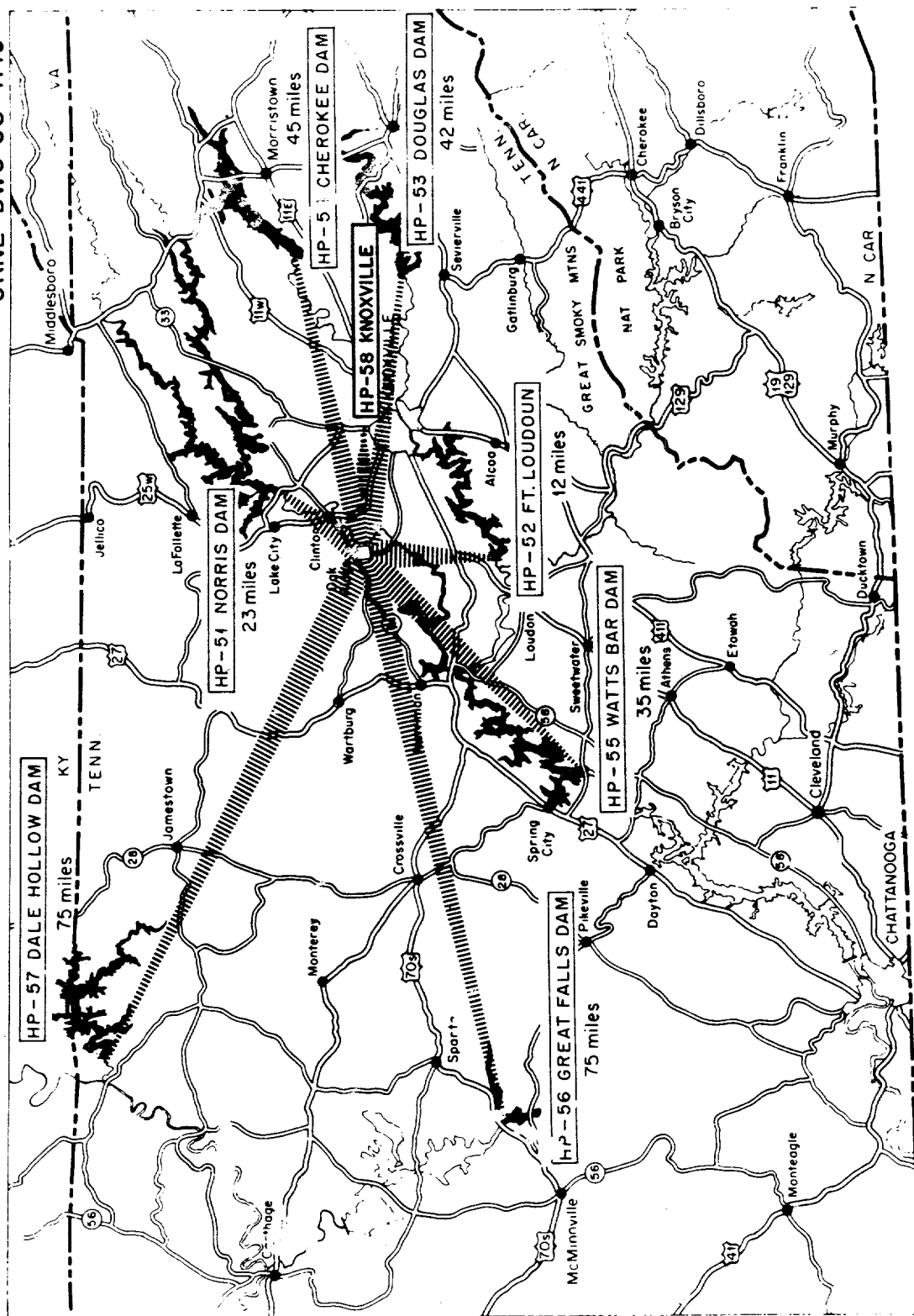


Fig. 4 Map of a Section of the East Tennessee Area Showing TVA and U.S. Corps. of Engineers Dam Sites at Which are Located the Remote Air Monitoring Stations Constituting the RAM Network.

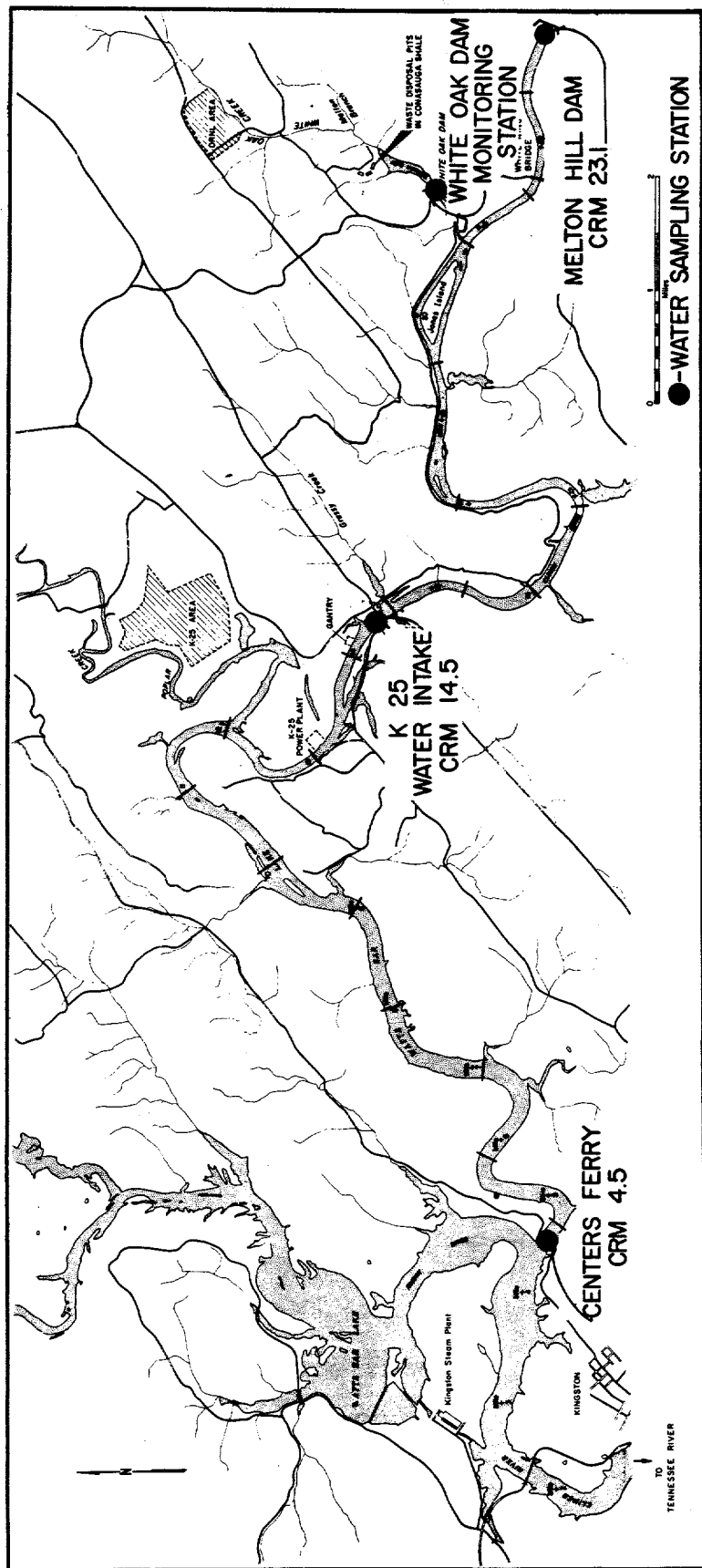


Fig. 5 Map Showing Water Sampling Locations in the East Tennessee Area.

Raw milk samples are collected at twelve sampling stations located within a radius of 50 miles from ORNL. Samples are taken on a weekly basis from eight stations which are located outside the AEC controlled area within a 12-mile radius of ORNL (Figure 6). Samples are collected every five weeks from the four remaining stations, all of which are located outside the 12-mile radius up to distances of about 50 miles. The purpose of the milk sampling program is twofold: first, samples collected in the immediate vicinity of ORNL provide data by which one may evaluate the possible effect of waste releases originating from ORNL operations; second, samples collected remote to the immediate vicinity of the ORNL area provide background data which are essential in establishing a proper index from which the intentional or accidental release of radioactive materials originating from Oak Ridge operations may be evaluated.

Thyroid tissues taken from cattle pastured within a radius of 100 miles of Oak Ridge are analyzed for radioiodine at the rate of six samples per week. These analyses provide information on background levels needed to identify environmental levels that might result from either continuous or sporadic releases of ^{131}I to the environment from ORNL and other Oak Ridge operations.

Aerial background surveys are made over the ORNL area and for several miles from ORNL in the general direction of low altitude prevailing winds. The frequency of flights has been established at once per quarter.

Background gamma radiation measurements are made monthly at a number of locations throughout other portions of the East Tennessee area. These measurements are taken with calibrated GM and scintillation type detectors at a distance of three feet above the surface of the ground.

River bottom sediments in the Clinch and Tennessee Rivers have been surveyed and analyzed annually since the year 1951 for the purpose of providing data relative to the dispersion of radioactive wastes released from Oak Ridge operations to the Clinch River.

5.1 Atmospheric Monitoring

5.1.1 Air Concentrations - The average concentrations of radioactive materials in the atmosphere, as measured by filtration methods provided by the LAM, PAM, and RAM networks during 1966, were as follows:

<u>Network</u>	<u>Concentration ($\mu\text{c/cc}$)</u>
LAM	0.17×10^{-12}
PAM	0.11×10^{-12}
RAM	0.11×10^{-12}

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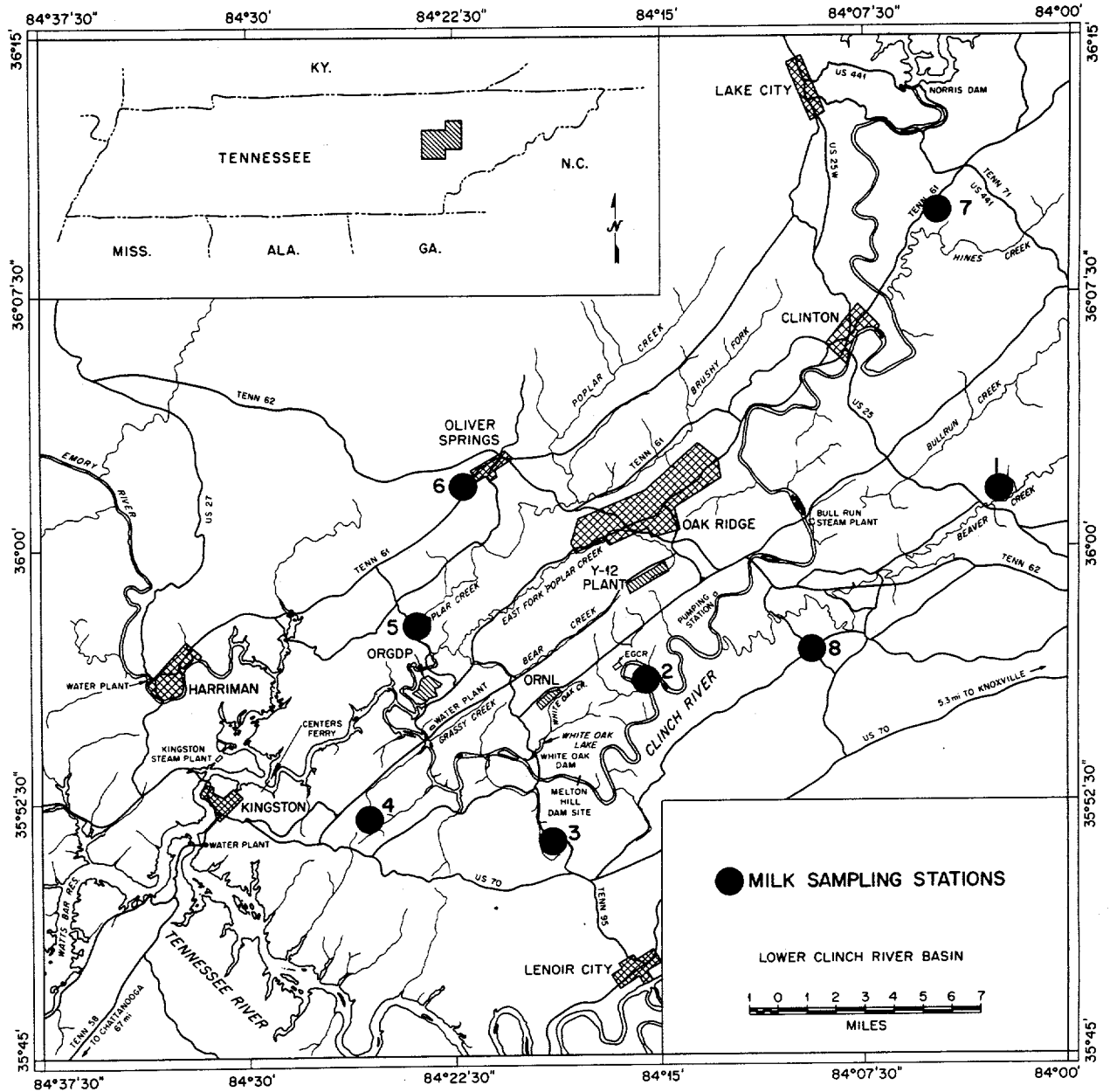


Fig. 6 Map Showing Milk Sampling Stations in the East Tennessee Area.

The LAM network value of 0.17×10^{-12} $\mu\text{c}/\text{cc}$ is about 0.02 percent of the $(\text{MPCU})_a^2$ based on occupational exposure. Both the PAM and RAM network values represent 0.1 percent of the $(\text{MPCU})_a$ for persons residing in the neighborhood of an atomic energy installation. A tabulation of data for each station in each network is given in Table 1. The weekly values for each network are illustrated in Figure 7.

The number of radioactive particles collected on air monitor filters of the LAM network in 1966 increased by a factor of 2 from the number collected in 1965. The values measured by the PAM and RAM networks increased by factors of 2.5 and 3.5 respectively. The average number of radioparticulates per 1000 cubic feet of air sampled at each station in each network is given in Table 1.

5.1.2 Fallout (Gummed Paper Technique) - Radioparticulate fallout as measured by the LAM network of stations increased by a factor of about 1.4 from the value measured in 1965. The values measured by the PAM and RAM networks increased by factors of 1.8 and 3.0 respectively from the 1965 values. The increase may be attributed to world wide fallout from weapons testing. Radioparticulate fallout showed a sharp rise in the East Tennessee area during the week ending May 16 and again during the week ending October 31. The arrival of the fallout material in the Oak Ridge area in both instances was consistent with the timing of announced nuclear detonations on the Chinese mainland on May 9, 1966 and again on October 27, 1966.³ Table 2 gives a tabulation of data for each station within each network. The weekly average values for each network for each week are illustrated in Figure 8.

5.1.3 Atmospheric Radioiodine (Charcoal Collector Techniques) - Atmospheric radioiodine measured by the perimeter stations averaged 0.014×10^{-12} $\mu\text{c}/\text{cc}$ during 1966. This is only about 0.01 percent of the maximum permissible concentration for populations in the neighborhood of a controlled area. The maximum value observed at any one station for one week was 0.12×10^{-12} $\mu\text{c}/\text{cc}$. This value was measured at PAM 38 and was associated with the release of about one curie of radioiodine from ORNL⁴ stacks during a period of one week. Figure 9 compares the weekly discharge of radioiodine from ORNL stacks⁵ with the average concentration of radioiodine measured by the perimeter stations.

²The $(\text{MPCU})_a$ is defined as the maximum permissible concentration for an unknown mixture of radioisotopes in air. NBS Handbook 69, Table 4, p. 94, gives exposure values applicable to various mixtures of radionuclides and establishes guide lines for deriving the $(\text{MPCU})_a$.

³Radiological Health Data, Volume 7, Number 6, June, 1966 and Number 11, November, 1966, U.S. Department of Health, Education and Welfare.

⁴"Summary of Waste Discharges", Week Ending May 15, 1966, L. C. Lasher.

⁵"Summary of Waste Discharges", Weekly Reports, 1966, L. C. Lasher.

Table 1 CONCENTRATION OF RADIOACTIVE MATERIALS IN AIR - 1966
(Filter Paper Data—Weekly Average)

Station Number	Location	Long-Lived Activity 10 ⁻¹³ μc/cc	No. of Particles by Activity Ranges					Particles Per 1000 ft ³
			< 10 ⁵ d/24 hr	10 ⁵ -10 ⁶ d/24 hr	10 ⁶ -10 ⁷ d/24 hr	> 10 ⁷ d/24 hr	Total	
Laboratory Area								
HP-1	S 3587	1.3	2.04	0.02	0.00	0.00	2.1	0.09
HP-2	NE 3025	2.0	2.8	0.04	0.00	0.00	2.9	0.15
HP-3	SW 1000	1.7	1.7	0.00	0.00	0.00	1.7	0.10
HP-4	W Settling Basin	1.7	2.3	0.02	0.00	0.00	2.4	0.13
HP-5	E 2506	2.0	2.7	0.04	0.00	0.00	2.8	0.15
HP-6	SW 3027	1.6	2.6	0.02	0.00	0.00	2.6	0.16
HP-7	W 7001	1.6	1.9	0.00	0.00	0.00	1.9	0.10
HP-8	Rock Quarry	1.7	1.6	0.00	0.00	0.00	1.6	0.09
HP-9	N Bethel Valley Rd.	1.9	2.0	0.00	0.00	0.02	2.0	0.11
HP-10	W 2075	1.5	2.7	0.00	0.00	0.00	2.7	0.13
HP-16	E 4500	1.9	2.7	0.00	0.00	0.00	2.7	0.15
HP-20	HFIR	1.8	2.9	0.00	0.00	0.00	2.9	0.16
Average		1.7	2.3	0.01	0.00	0.00	2.3	0.13
Perimeter Area								
HP-31	Kerr Hollow Gate	1.0	3.4	0.02	0.00	0.00	3.4	0.07
HP-32	Midway Gate	1.1	3.1	0.02	0.00	0.00	3.1	0.06
HP-33	Gallaher Gate	0.8	1.8	0.06	0.00	0.00	1.9	0.04
HP-34	White Wing Gate	0.9	2.6	0.00	0.00	0.00	2.6	0.06
HP-35	Blair Gate	1.1	4.3	0.06	0.00	0.00	4.3	0.08
HP-36	Turnpike Gate	1.6	2.5	0.04	0.02	0.00	2.6	0.05
HP-37	Hickory Creek Bend	0.8	4.1	0.00	0.00	0.00	4.1	0.08
HP-38	E EGCR	1.1	2.3	0.00	0.00	0.00	2.3	0.07
HP-39	Townsite	1.2	3.3	0.00	0.00	0.00	3.3	0.10
Average		1.1	3.1	0.02	0.00	0.00	3.1	0.07
Remote Area								
HP-51	Norris Dam	1.1	3.3	0.04	0.00	0.00	3.3	0.06
HP-52	Loudoun Dam	1.1	3.1	0.02	0.00	0.00	3.1	0.05
HP-53	Douglas Dam	1.1	3.0	0.04	0.00	0.00	3.1	0.06
HP-54	Cherokee Dam	1.0	4.2	0.06	0.00	0.00	4.2	0.07
HP-55	Watts Bar Dam	1.0	3.5	0.00	0.00	0.00	3.5	0.07
HP-56	Great Falls Dam	1.2	4.9	0.04	0.00	0.00	4.9	0.10
HP-57	Dale Hollow Dam	1.0	4.3	0.00	0.00	0.00	4.3	0.08
HP-58	Knoxville	1.2	3.8	0.02	0.00	0.00	3.8	0.08
Average		1.1	3.8	0.03	0.00	0.00	3.8	0.07

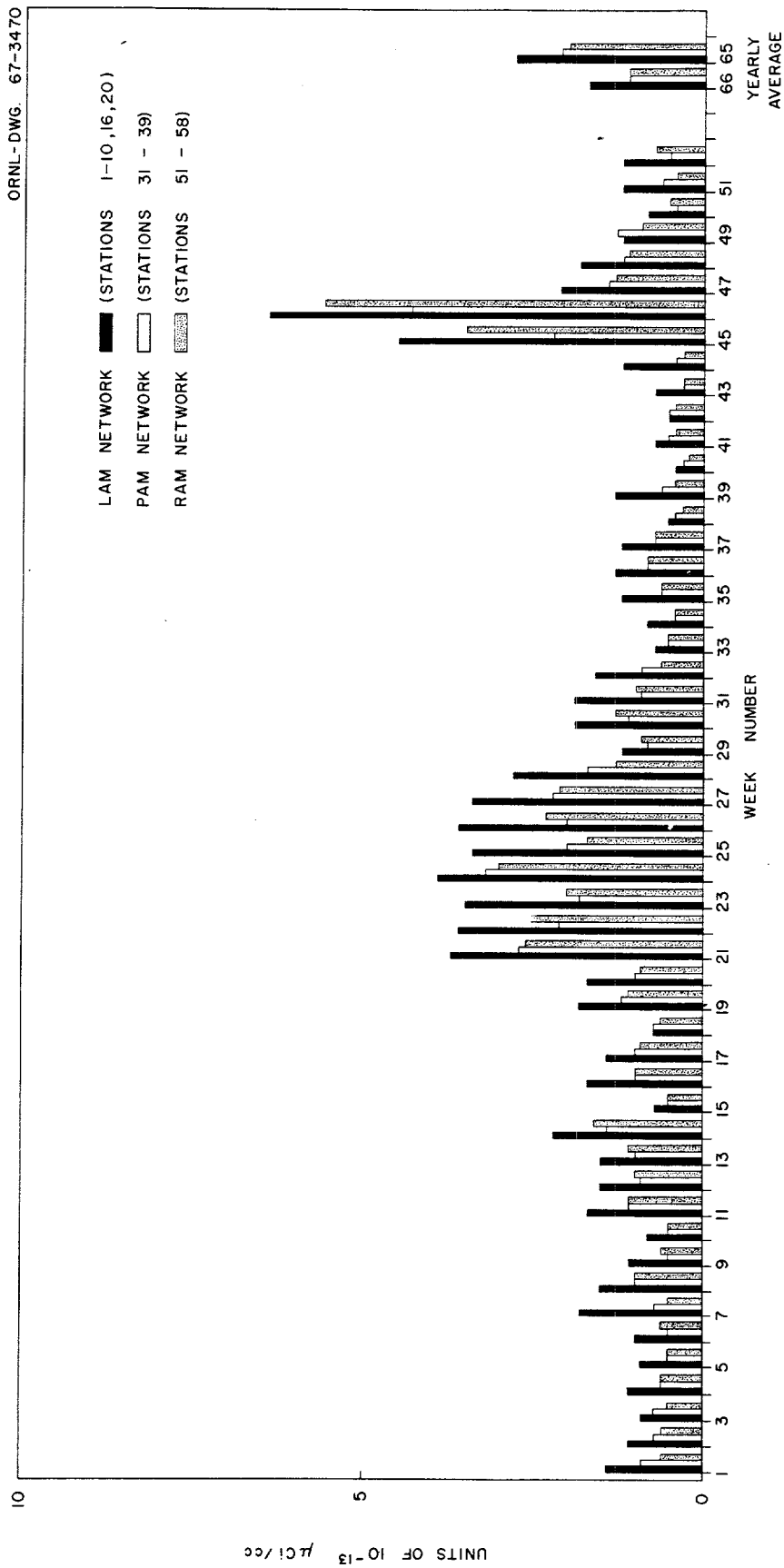


Fig. 7 Concentration of Radioactive Materials in Air as Determined from Filter Paper Data - 1966.

Table 2 RADIOPARTICULATE FALLOUT—1966
(Gummed Paper Data—Weekly Average)

Station Number	Location	Long-Lived Activity 10 ⁻⁴ μc/ft ²	No. of Particles by Activity Ranges				Total Particles Per Sq. Ft.
			< 10 ⁵ d/24 hr	10 ⁵ -10 ⁶ d/24 hr	10 ⁶ -10 ⁷ d/24 hr	> 10 ⁷ d/24 hr	
Laboratory Area							
HP-1	S 3587	0.73	1.37	0.17	0.00	0.00	1.54
HP-2	NE 3025	1.3	2.17	0.25	0.00	0.00	2.42
HP-3	SW 1000	0.74	1.60	0.17	0.00	0.00	1.77
HP-4	W Settling Basin	0.88	1.81	0.33	0.00	0.00	2.13
HP-5	E 2506	1.1	2.44	0.08	0.02	0.00	2.54
HP-6	SW 3027	1.8	2.49	0.31	0.04	0.02	2.87
HP-7	W 7001	0.54	1.38	0.25	0.00	0.00	1.63
HP-8	Rock Quarry	0.61	1.79	0.21	0.00	0.00	2.00
HP-9	N Bethel Valley Rd.	0.59	1.65	0.15	0.00	0.00	1.81
HP-10	W 2075	0.92	2.30	0.00	0.00	0.00	2.30
*HP-16	E 4500	0.22	0.48	0.00	0.00	0.00	0.48
*HP-20	HFIR	0.37	0.91	0.17	0.00	0.00	1.09
Average		0.85	1.79	0.18	0.01	0.00	1.98
Perimeter Area							
HP-31	Kerr Hollow Gate	0.58	1.58	0.35	0.00	0.00	1.92
HP-32	Midway Gate	0.65	1.33	0.06	0.00	0.00	1.38
HP-33	Gallaher Gate	0.58	1.40	0.19	0.00	0.00	1.60
HP-34	White Wing Gate	0.54	1.15	0.13	0.00	0.00	1.29
HP-35	Blair Gate	0.66	1.88	0.19	0.00	0.00	2.08
HP-36	Turnpike Gate	0.48	1.36	0.13	0.00	0.00	1.44
HP-37	Hickory Creek Bend	0.51	1.58	0.13	0.00	0.00	1.71
HP-38	E EGCR	0.71	1.17	0.19	0.04	0.00	1.40
HP-39	Townsite	0.65	1.63	0.10	0.00	0.02	1.75
Average		0.60	1.45	0.16	0.00	0.00	1.62
Remote Area							
HP-51	Norris Dam	0.51	0.85	0.17	0.00	0.00	1.02
HP-52	Loudoun Dam	0.70	1.06	0.29	0.00	0.00	1.35
HP-53	Douglas Dam	0.69	1.08	0.31	0.00	0.00	1.38
HP-54	Cherokee Dam	0.61	1.68	0.20	0.00	0.00	1.88
HP-55	Watts Bar Dam	0.42	1.19	0.23	0.02	0.00	1.44
HP-56	Great Falls Dam	0.55	2.25	0.19	0.00	0.00	2.44
HP-57	Dale Hollow Dam	0.85	0.79	0.13	0.02	0.00	0.96
HP-58	Knoxville	0.70	2.46	0.29	0.00	0.00	2.75
Average		0.63	1.42	0.23	0.00	0.00	1.65

*Installed July, 1966.

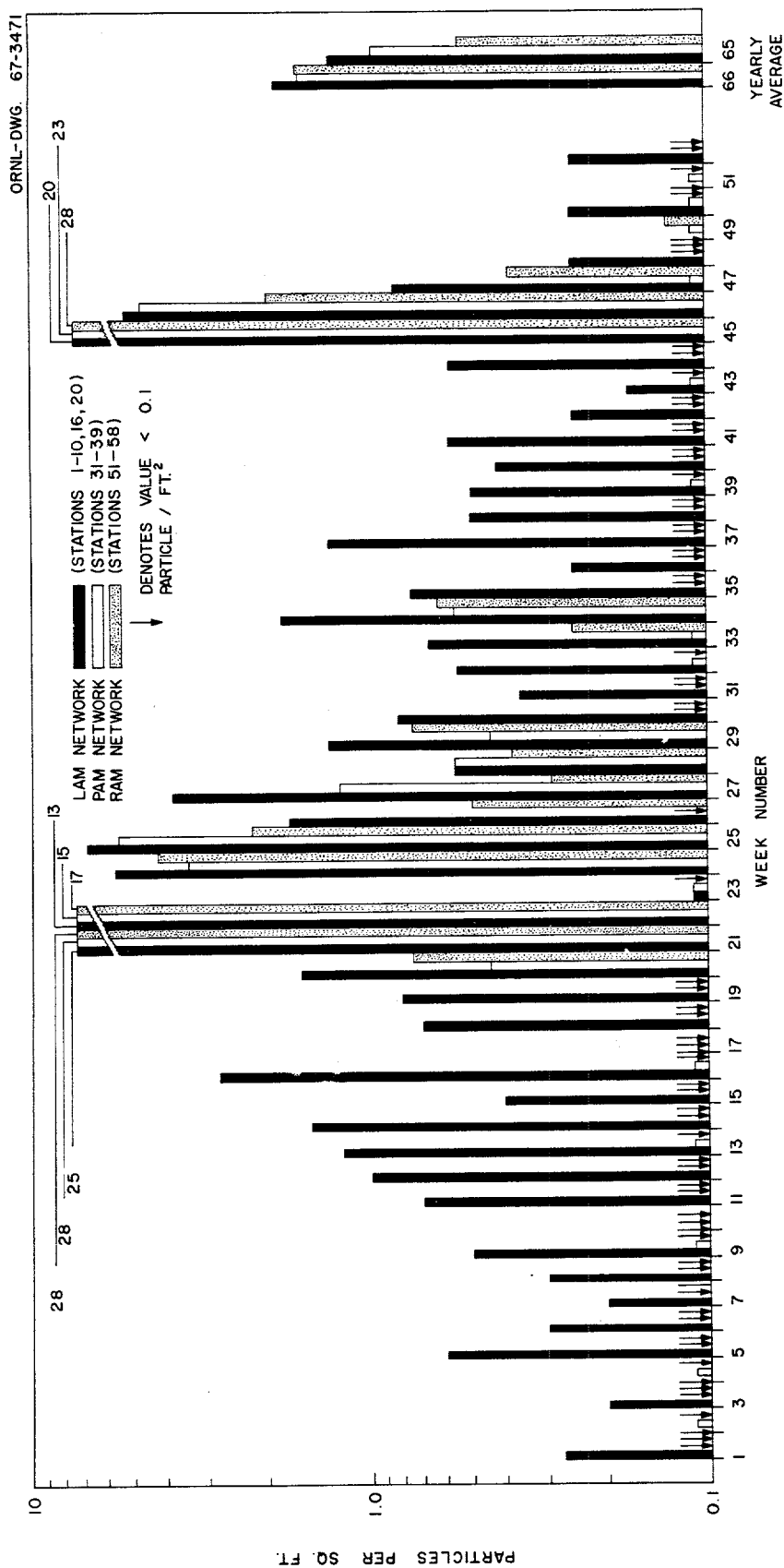


Fig. 8 Radioparticulate Fallout Measurements as Determined by Autoradiographic Techniques Using Gummed Paper Collectors - 1966.

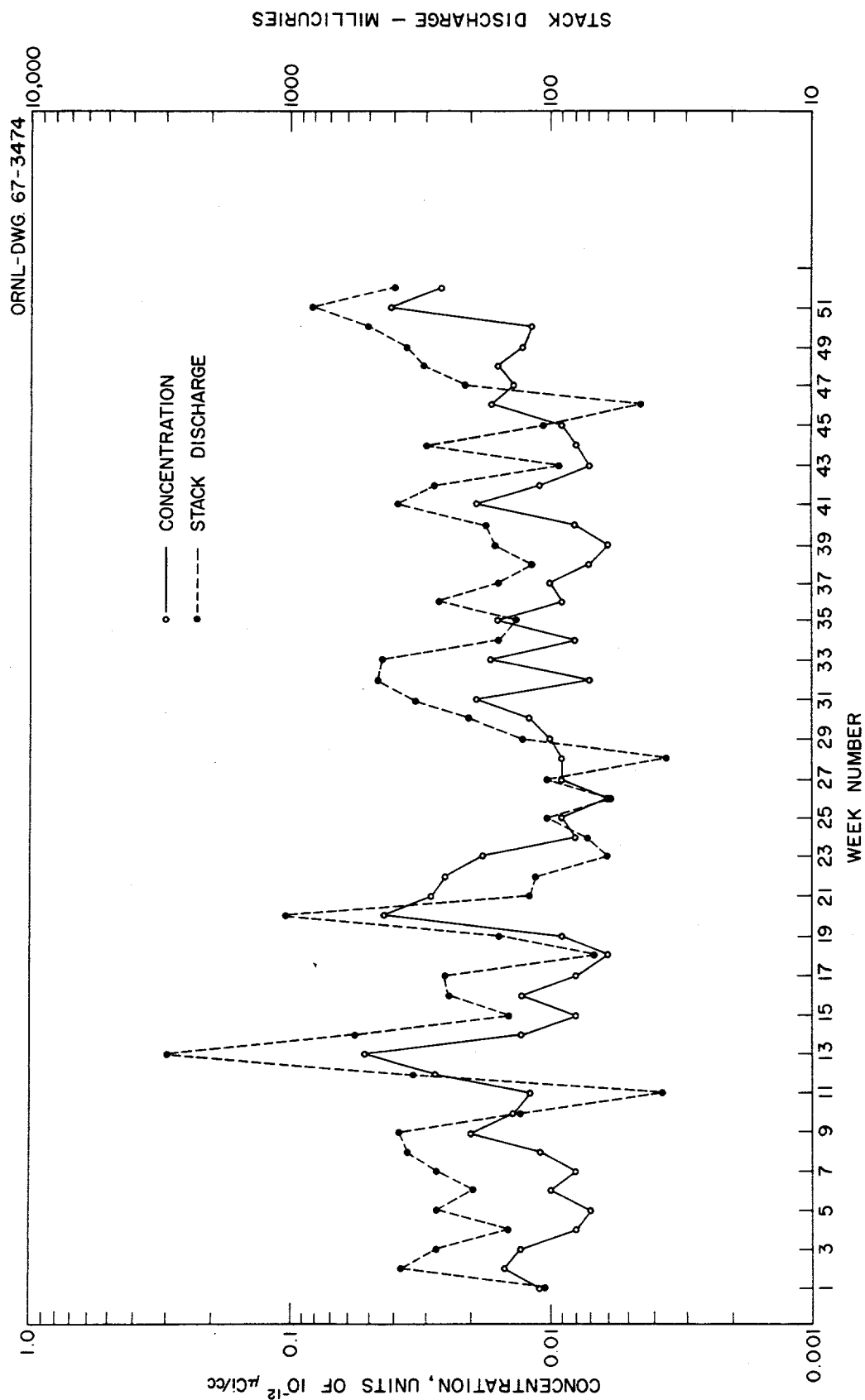


Fig. 9 Weekly Average Concentration of ^{131}I in Air at the Perimeter of the Controlled Area Compared with ^{131}I Discharges from ORNL Stacks - 1966.

The average radioiodine concentration measured by the local stations was 0.23×10^{-12} $\mu\text{c/cc}$. This is about 0.02% of the maximum permissible concentration for occupational exposure. The maximum value observed on any one station for one week was 3.3×10^{-12} $\mu\text{c/cc}$. This value was observed at LAM 4 (near the waste treatment plant). Table 3 gives ^{131}I data for both the Plant area (LAM's) and the perimeter area monitors.

5.2 Water Analyses

5.2.1 Rain Water - The average concentration of radioactivity in rain water collected from the three networks during 1966 were as follows:

<u>Network</u>	<u>Concentration ($\mu\text{c/ml}$)</u>
LAM	0.23×10^{-7}
PAM	0.35×10^{-7}
RAM	0.37×10^{-7}

These values are lower than those observed during 1965 by about 25 percent. The average values for each station are shown in Table 4; the average values for each network for each week are given in Figure 10.

5.2.2 Clinch River Water - A total of 48 beta curies of radioactivity was released to the Clinch River during 1966 as compared to 95 for 1965 (Table 5). Yearly discharges of radionuclides to Clinch River, 1949 through 1966, are shown in Table 6. Radiochemical analysis of the White Oak Dam effluent indicated that about 59 percent of the radioactivity was ^{106}Ru . The percentage of ^{90}Sr in the effluent was 6.2 compared to 3.6 in 1965.

The calculated average concentration of radioactive materials in the Clinch River at Clinch River Mile (CRM) 20.8 (the point of entry of White Oak Creek into the river) was 0.60×10^{-7} $\mu\text{c/ml}$. This represents only 1.9 percent of the weighted average $(\text{MPC})_w$ recommended for persons residing in the neighborhood of an atomic energy installation (Table 7). The average concentration of radioactive materials in the Clinch River did not exceed 9.7 percent of the $(\text{MPC})_w$ during any week in 1966 (Figure 11).

The measured average concentration of radioactivity in Clinch River water at CRM 23.1 (above the entry of White Oak Creek) was 0.31 percent of the weighted average $(\text{MPC})_w$ (Table 7). The concentration of ^{90}Sr in the river above the entry of White Oak Creek continues to be about the same as the contribution calculated for White Oak Creek effluent at CRM 20.8 assuming uniform mixing of the two streams.

The measured average concentration of radioactive materials in the Clinch River at CRM 4.5 (near Kingston, Tennessee) was 1.2×10^{-8} $\mu\text{c/ml}$. This value represents 0.76 percent of the $(\text{MPC})_w$ as applied to persons living in the neighborhood of an atomic energy installation.

Table 3 CONCENTRATION OF ^{131}I IN AIR—1966

Location	Units of 10^{-12} $\mu\text{c}/\text{cc}$		
	Maximum	Minimum ^a	Average
ORNL Plant Area	3.3	< 0.020	0.23
Perimeter Area	0.13	< 0.010	0.014

^a Minimum detectable amount of ^{131}I is 20 d/m. At the average sampling rate and this corresponds to approximately 0.010×10^{-12} $\mu\text{c}/\text{cc}$ on the perimeter monitors and approximately 0.020×10^{-12} $\mu\text{c}/\text{cc}$ on the Plant monitors. In averaging, one-half of this value, 10 d/m is used for all samples showing a total amount of ^{131}I less than 20 d/m.

Table 4 CONCENTRATION OF RADIOACTIVE MATERIALS IN RAINWATER—1966
(Weekly Average by Stations)

Station Number	Location	Activity in Collected Rainwater, $\mu\text{c}/\text{ml}$
Laboratory Area		
HP-7	West 7001	$0.23 \times 10^{-7} \mu\text{c}/\text{ml}$
Perimeter Area		
HP-31	Kerr Hollow Gate	$0.29 \times 10^{-7} \mu\text{c}/\text{ml}$
HP-32	Midway Gate	0.36
HP-33	Gallaher Gate	0.45
HP-34	White Wing Gate	0.46
HP-35	Blair Gate	0.29
HP-36	Turnpike Gate	0.36
HP-37	Hickory Creek Bend	0.35
HP-38	E EGCR	0.31
HP-39	Townsite	0.23
Average		$0.35 \times 10^{-7} \mu\text{c}/\text{ml}$
Remote Area		
HP-51	Norris Dam	$0.51 \times 10^{-7} \mu\text{c}/\text{ml}$
HP-52	Loudoun Dam	0.34
HP-53	Douglas Dam	0.30
HP-54	Cherokee Dam	0.41
HP-55	Watts Bar Dam	0.32
HP-56	Great Falls Dam	0.37
HP-57	Dale Hollow Dam	0.36
HP-58	Knoxville	0.38
Average		$0.37 \times 10^{-7} \mu\text{c}/\text{ml}$

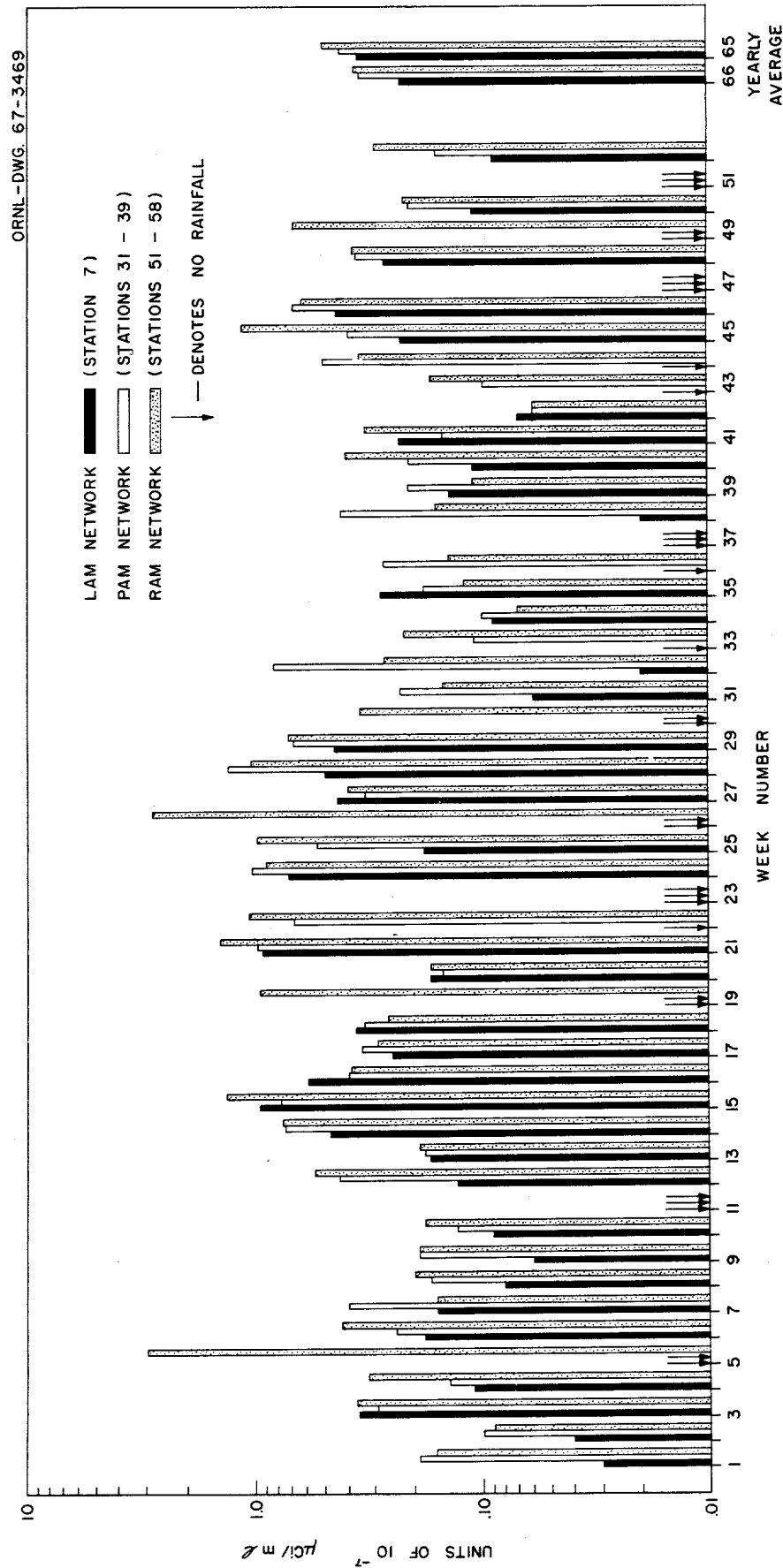


Fig. 10 Concentration of Radioactive Materials in Rainwater - 1966.

Table 5 LIQUID WASTES DISCHARGED FROM WHITE
OAK CREEK—1966

	Curies	
	Total for Year	Weekly Average
Beta Activity	148	0.93
Transuranic Alpha Emitters	0.16	0.003

Table 6 YEARLY DISCHARGES OF RADIONUCLIDES TO CLINCH RIVER (CURIES)

Year	Gross Beta	¹³⁷ Cs	¹⁰⁶ Ru	⁹⁰ Sr	TRE* (-Ce)	¹⁴⁴ Ce	⁹⁵ Zr	⁹⁵ Nb	¹³¹ I	⁶⁰ Co
1949	718	77	110	150	77	18	180	22	77	
1950	191	19	23	38	30		15	42	19	
1951	101	20	18	29	11		4.5	2.2	18	
1952	214	9.9	15	72	26	23	19	18	20	
1953	304	6.4	26	130	110	6.7	7.6	3.6	2.1	
1954	384	22	11	140	160	24	14	9.2	3.5	
1955	437	63	31	93	150	85	5.2	5.7	7.0	6.6
1956	582	170	29	100	140	59	12	15	3.5	46
1957	397	89	60	83	110	13	23	7.1	1.2	4.8
1958	544	55	42	150	240	30	6.0	6.0	8.2	8.7
1959	937	76	520	60	94	48	27	30	0.5	77
1960	2190	31	1900	28	48	27	38	45	5.3	72
1961	2230	15	2000	22	24	4.2	20	70	3.7	31
1962	1440	5.6	1400	9.4	11	1.2	2.2	7.7	0.36	14
1963	470	3.5	430	7.8	9.4	1.5	0.34	0.71	0.44	14
1964	234	6.0	191	6.6	13	0.3	0.16	0.07	0.29	15
1965	95	2.1	69	3.4	5.9	0.1	0.33	0.33	0.20	12
1966	48	1.6	29	3.0	4.9	0.1	0.67	0.67	0.24	7

*Total Rare Earths.

Table 7 RADIOACTIVITY IN CLINCH RIVER—1966

Location	Concentration of Radionuclides of Primary Concern in Units of 10^{-8} $\mu\text{C}/\text{ml}$					Average Concentration of Total Radioactivity 10^{-8} $\mu\text{C}/\text{ml}$	$(\text{MPC})_w^a$ 10^{-6} $\mu\text{C}/\text{ml}$	% of $(\text{MPC})_w^a$
	^{90}Sr	^{144}Ce	^{137}Cs	$^{103-106}\text{Ru}$	^{60}Co	^{95}Zr - ^{95}Nb		
CRM 23.1 ^b	0.09	0.03	0.03	0.06	*	*	0.20	0.67
CRM 20.8 ^c	0.09	0.03	0.05	0.81	0.21	< 0.01	6.0	3.1
CRM 4.5 ^b	0.21	0.06	0.16	0.39	0.37	< 0.01	1.2	1.6
								0.76

^aWeighted average $(\text{MPC})_w$ calculated for the mixture, using $(\text{MPC})_w$ values for specific radionuclides specified by AEC Manual, Chapter 0524, Appendix, Annex 1, Table II.

^bMeasured values.

^cValues given for this location are calculated values based on the levels of waste released and the dilution afforded by the river; they do not include amounts of radioactive material (e.g., fallout) that may enter the river upstream from CRM 20.8.

* None detected.

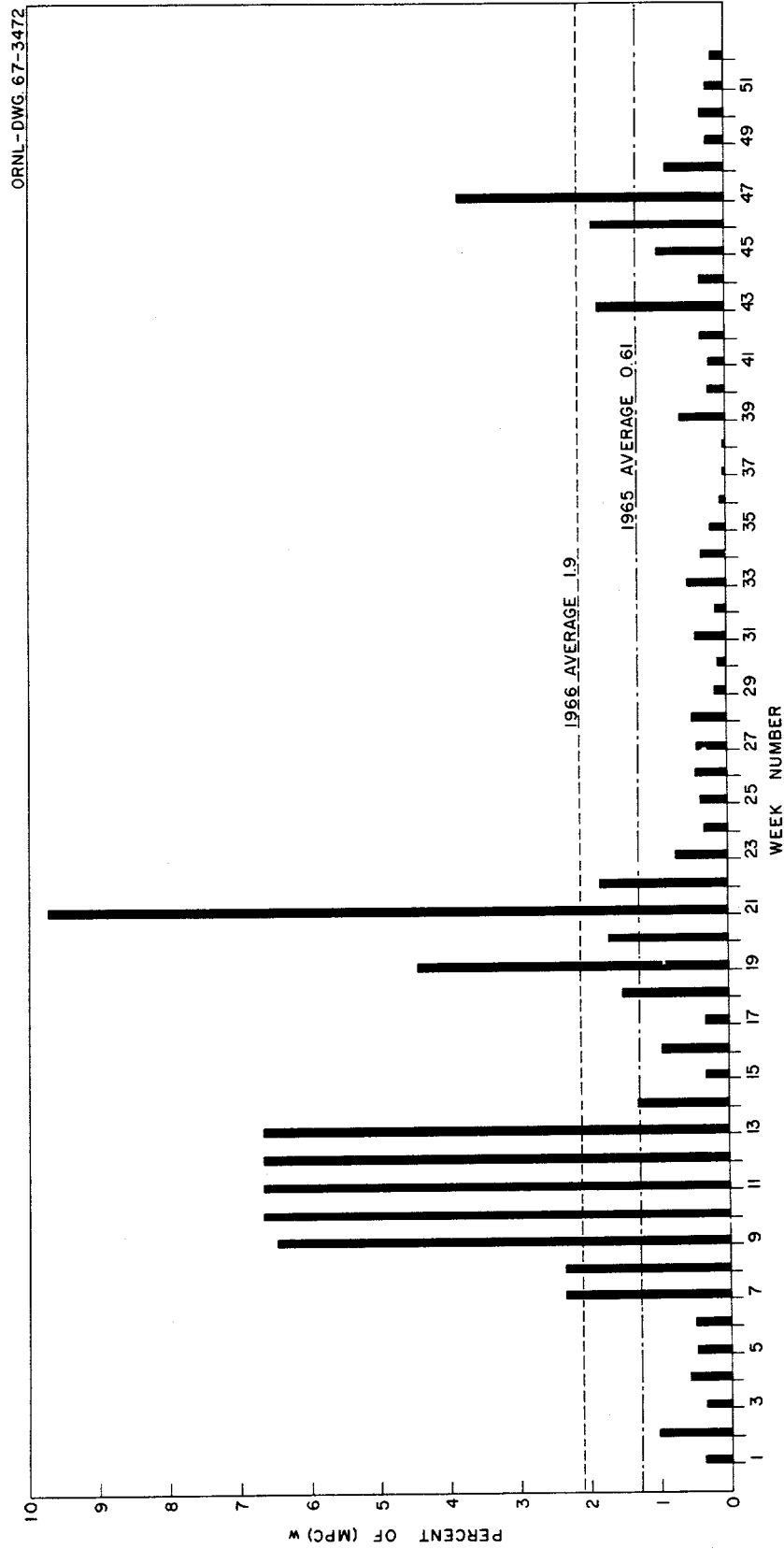


Fig. 11 Estimated Percent (MPC)_w of Radioactivity in Clinch River Water Below the Mouth of White Oak Creek - 1966.

5.2.3 Potable Water - The average concentrations of ^{90}Sr in potable water at ORNL during 1966 were as follows:

<u>Quarter Number</u>	<u>Concentration ^{90}Sr ($\mu\text{c}/\text{ml}$)</u>
1	0.9×10^{-9}
2	0.9×10^{-9}
3	0.9×10^{-9}
4	0.45×10^{-9}
Average for Year	0.79×10^{-9}

The average value of 0.79×10^{-9} represents 0.26 percent of the $(\text{MPC})_w$ as applied to persons residing in the neighborhood of an atomic energy installation.

Based on gamma spectrometric analyses, no long-lived gamma emitting radionuclides were detected in ORNL potable water during 1966.

5.3 Milk Analyses

The average concentration of ^{90}Sr in raw milk samples collected within a 12-mile radius of the Laboratory during 1966 was 26.1 pc/l. The average concentration of ^{90}Sr in samples collected between 12 miles and 50 miles from the Laboratory was 24.4 pc/l. These results would indicate that the ^{90}Sr content of milk in the Oak Ridge area is largely the result of fallout from previous world wide weapons tests. Figure 12 presents the weekly average concentration of ^{90}Sr in raw milk sampled from the immediate environs of Oak Ridge.

The average concentration of ^{131}I in raw milk samples collected within a 12-mile radius of the Laboratory during 1966 was 9.0 pc/l. Figure 13 presents the weekly average concentrations of ^{131}I in raw milk collected at these stations compared with the weekly discharges of ^{131}I from the ORNL stacks. The peak concentration occurred during week 21 and may be attributed to the announced nuclear detonation on the Chinese mainland on May 6, 1967.⁶ It should be noted that the yearly average concentration is below the lower limit of FRC Range II daily intake guide for ^{131}I , if one assumes an intake of 1 liter of milk per day, and that at no time during the year did the weekly average concentration exceed the upper limit of FRC Range II.

⁶Radiological Health Data, Volume 7, Number 6, June, 1966, U.S. Department of Health, Education and Welfare.

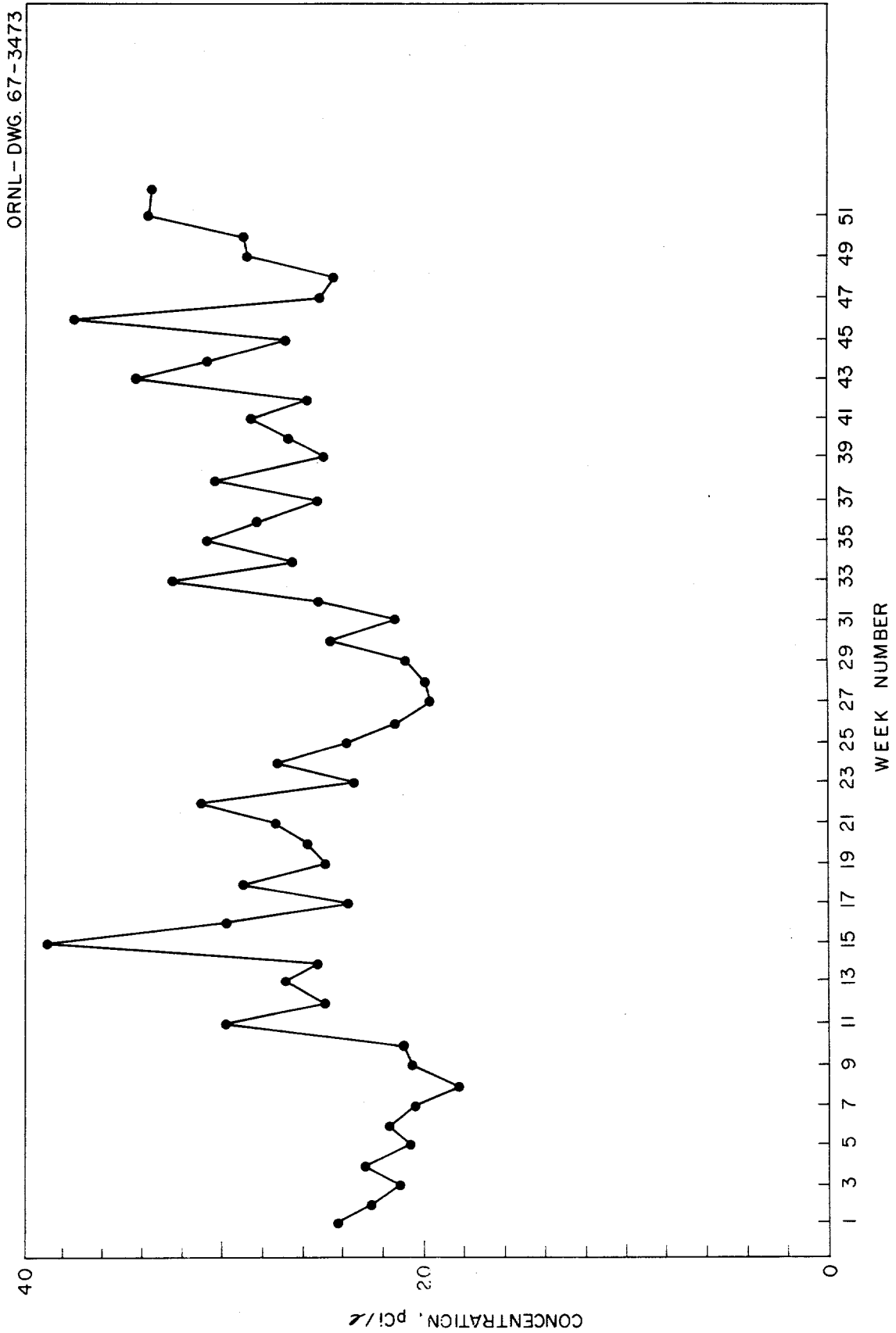


Fig. 12 Weekly Average Concentration of ^{90}Sr in Raw Milk in the Immediate Environs of Oak Ridge - 1966.

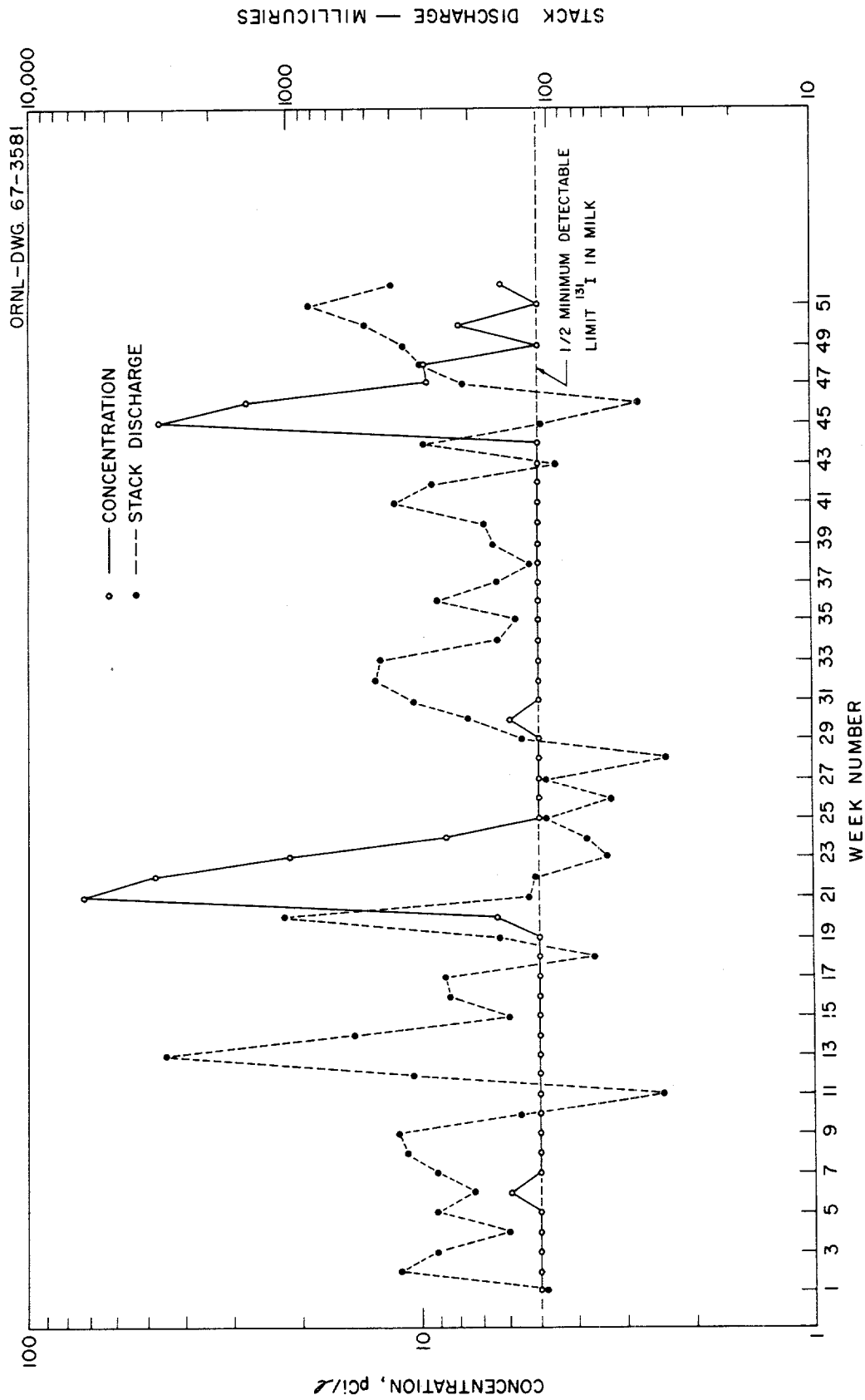


Fig. 13 Weekly Average Concentration of ^{131}I in Raw Milk in the Immediate Environs of Oak Ridge Compared with ^{131}I Discharges from ORNL Stacks - 1966.

5.4 Background Measurements

Background measurements were taken at a number of locations (established in 1961) in the East Tennessee area during routine servicing visits to the remote air monitoring stations. Measurements were made at each location on a frequency of once each five weeks. The average background level during 1966 as measured at these stations was 0.012 mR/hr. Average background readings and the location of each station are presented in Figure 14.

Background measurements made monthly with a calibrated GM monitor at five selected locations adjacent to the ORNL area yielded an average background reading of 0.012 mR/hr during 1966. Corresponding measurements made at 53 locations on the ORNL site gave an average background of 0.075 mR/hr. The average background level measured in the Oak Ridge area in 1943 prior to the start-up of the Oak Ridge Graphite Reactor was 0.012 mR/hr. A comparison of average background values taken both on and off the X-10 site for the years 1957-66 is presented in Figure 15.

5.5 Annual Survey of the Clinch and Tennessee Rivers

The 1966 survey of the Clinch and Tennessee Rivers extended downstream through Kentucky Reservoir. Twenty-five traverses were made in 1966 as compared to 19 in 1965. The same expanse of the Clinch River was covered as in 1965 and the same expanse of the Tennessee River was covered as far downstream as Watts Bar Dam where the 1965 survey terminated. In 1966 the expanse of the Tennessee River from Watts Bar Dam downstream to Kentucky Dam was spot checked to running one traverse just upstream from each dam with the exception of Hales Bar. The techniques and procedures used are described in ORNL 2847, "Radioactivity in Silt of the Clinch and Tennessee Rivers".

The 1966 survey showed the dispersal pattern of radioactive silt in the Clinch River to be essentially the same as in 1965 except for the slightly higher levels of radioactivity measured. These higher levels were measured at all points in the Clinch except in the lower reaches (Figure 16). The higher levels measured in the upper reaches of the river were, in all probability, due to the low flow in the river during the six months just preceding the survey. During this period (first half of 1966) the activity discharged (66% of the total for the year) would have been subjected to less turbulent flow and consequently settled to the bottom farther upstream than normal.

The average gamma count rate on bottom silt located in Melton Hill Reservoir on the Clinch River and in Watts Bar Reservoir on the Tennessee River showed a slight decrease from that measured in 1965 (Figure 17 and Figure 18). Compared with 1951 data, the 1966 count rate is considerably lower in both Watts Bar and Chickamauga Reservoirs and essentially the same downstream through Kentucky Reservoir (Figure 18).

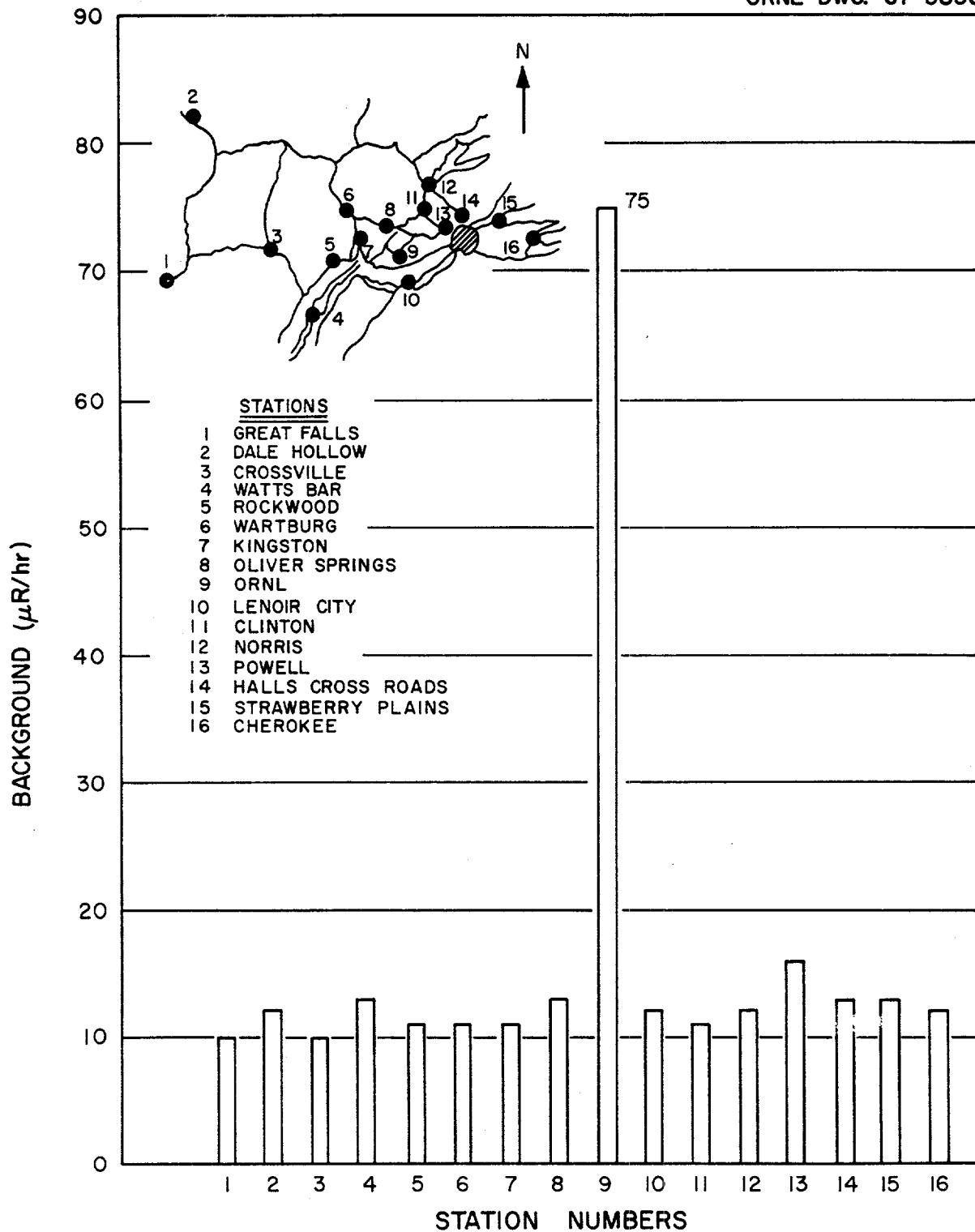


Fig. 14 Radiation Measurements Taken During 1966, 3 ft. Above the Ground Surface out to Distances of 75 Miles from ORNL.

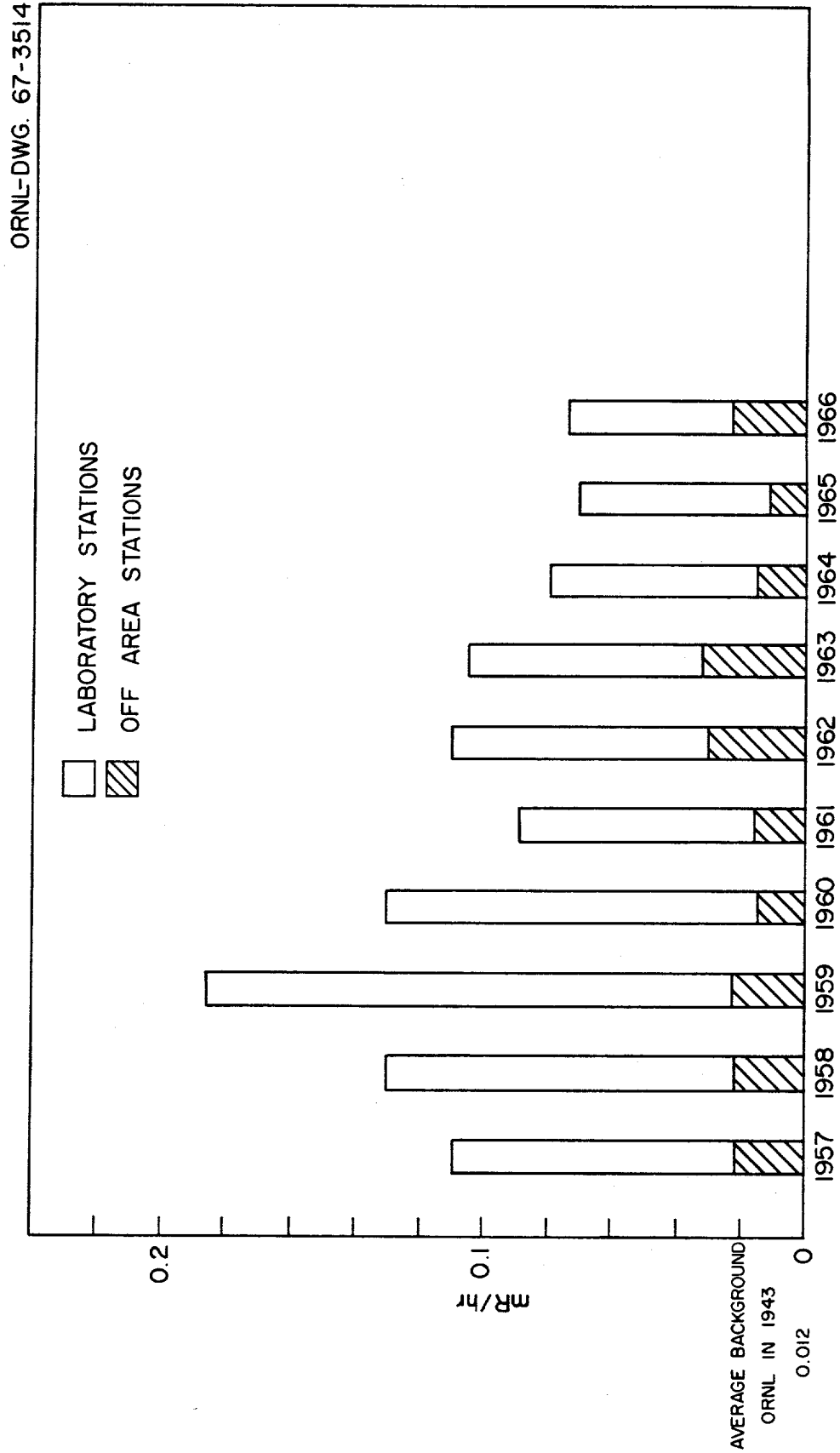


Fig. 15 Radiation Measurements Taken 3 ft. Above the Ground Surfaces at ORNL Compared with Like Measurements Taken Elsewhere within the AEC Controlled Area for the Years 1957-1966.

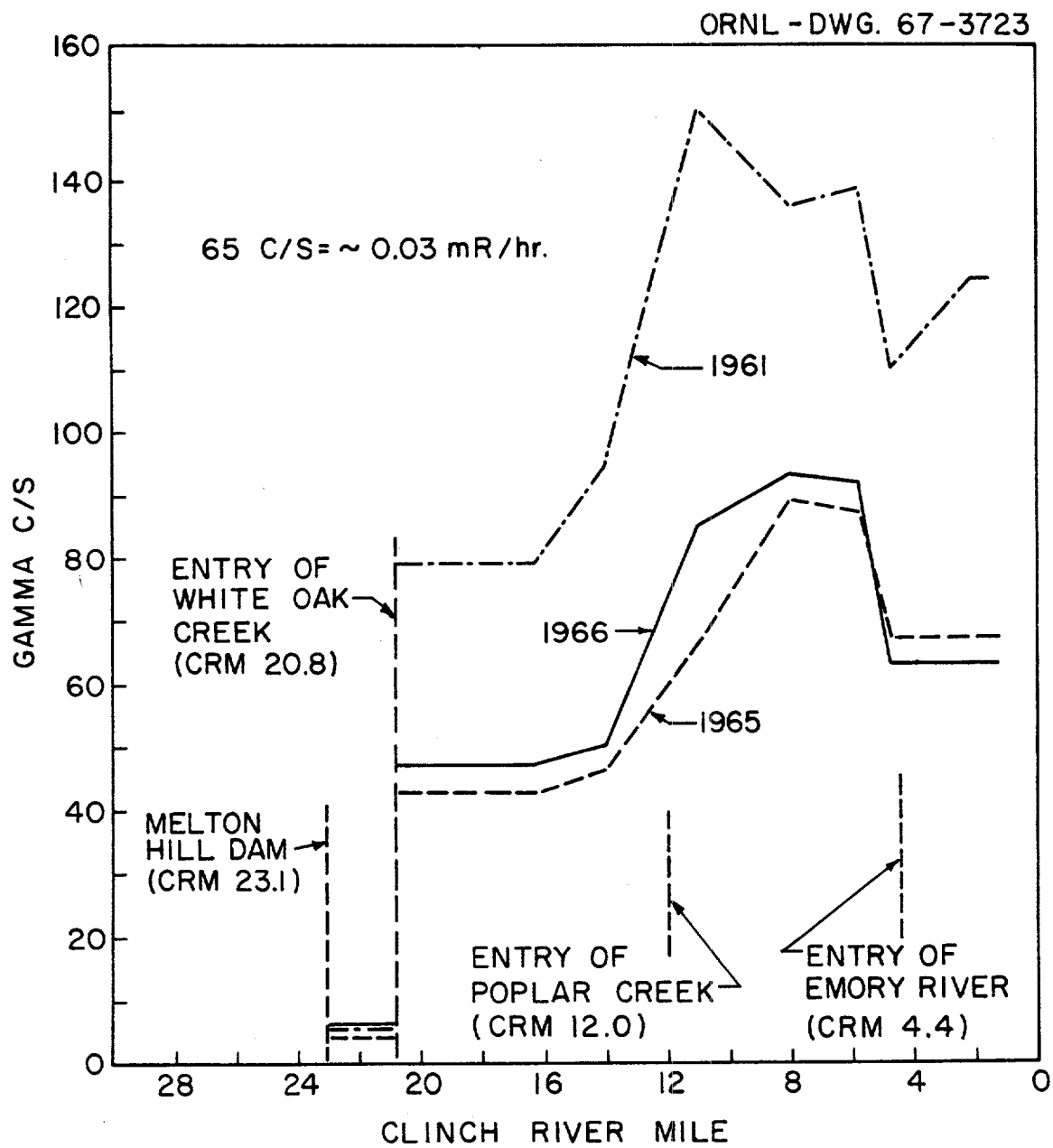


Fig. 16 Gamma Count at the Surface of Clinch River Silt.

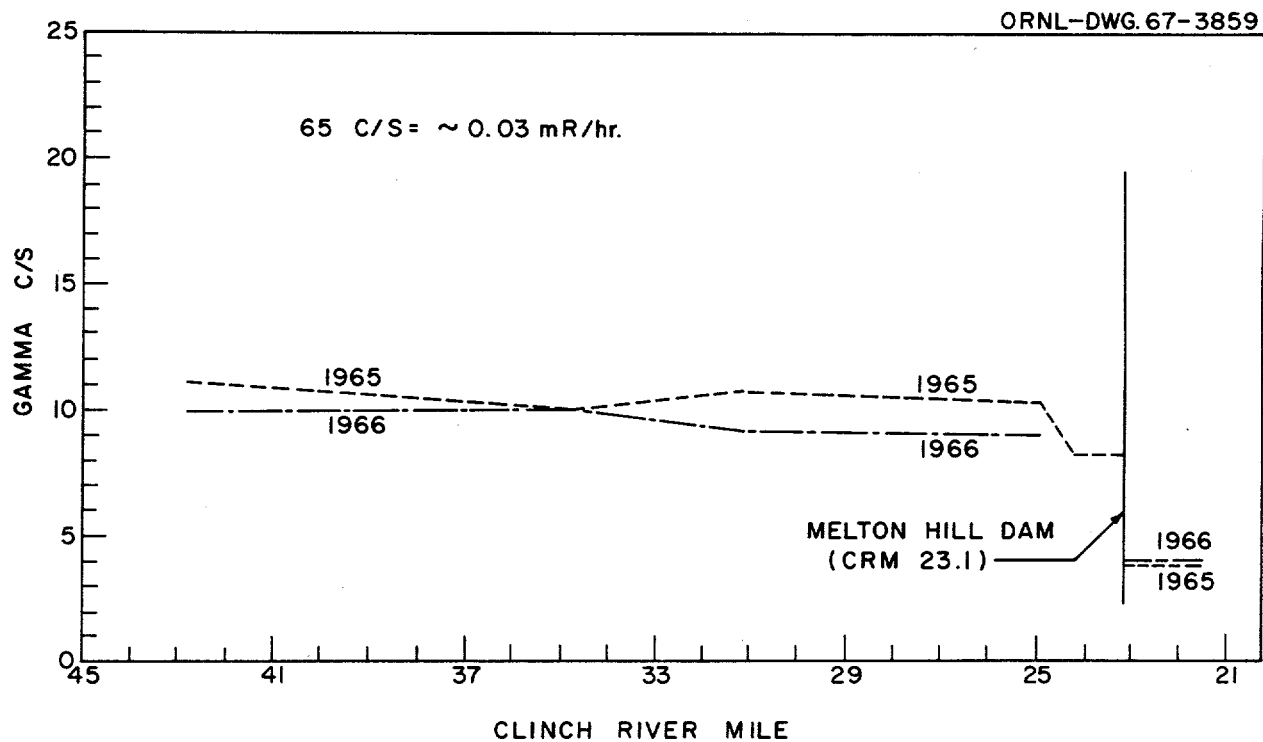


Fig. 17 Gamma Count at the Surface of Clinch River Silt - Melton Hill Reservoir.

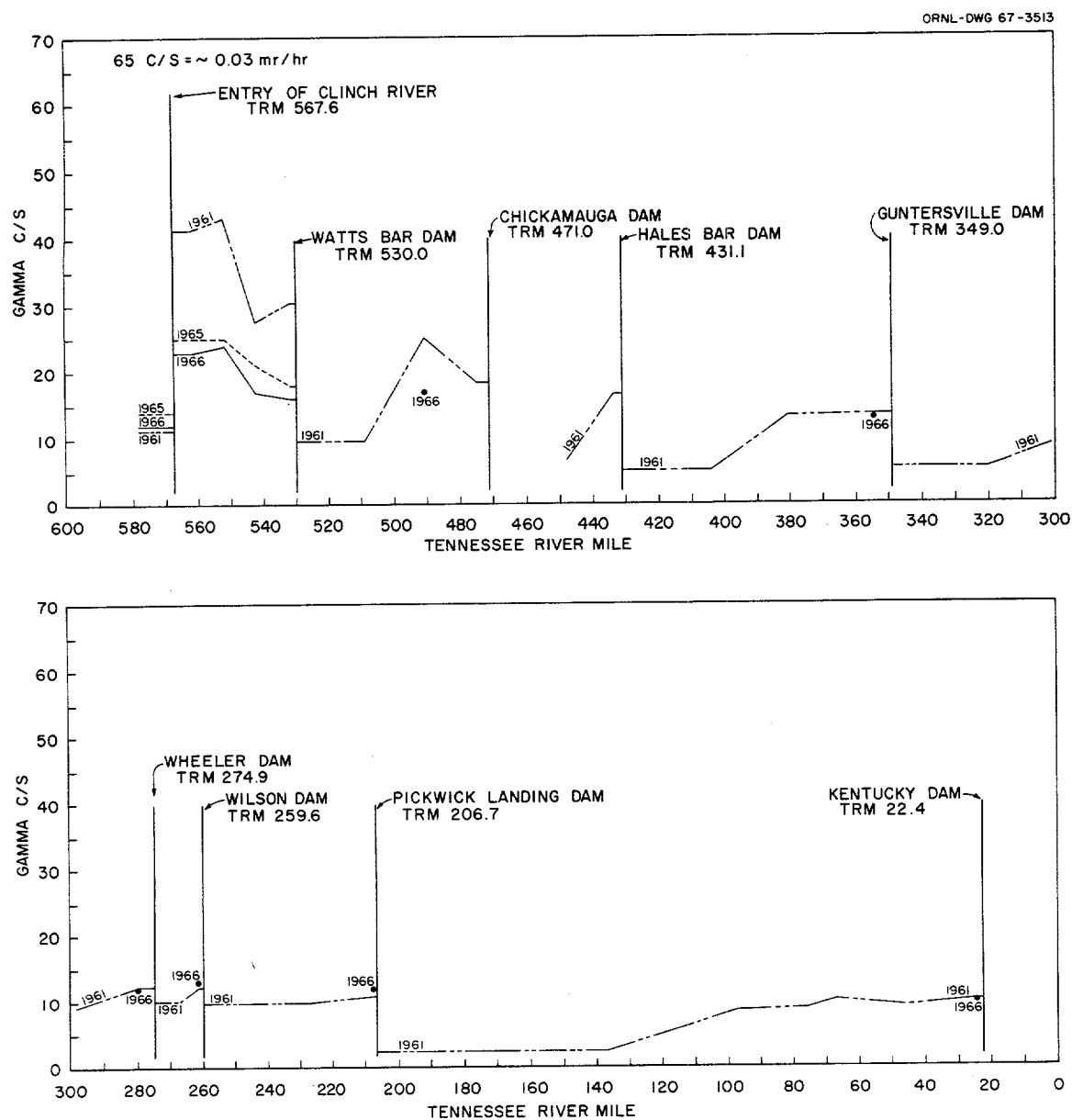


Fig. 18 Gamma Count at the Surface of Tennessee River Silt.

Radiochemical analysis data obtained from the Clinch and Tennessee River silt collected in 1965 and 1966 are given in Table 8. Table 9 compares the data from 1966 survey with the data from the 1961 survey (the last previous survey of this stretch of river) downstream from TRM 532.0.

Table 8 RADIONUCLIDES IN CLINCH AND TENNESSEE RIVER SILT--1965-1966
(Units of 10^{-6} $\mu\text{Ci/g}$ of Dried Silt)

Location	^{137}Cs		^{144}Ce		^{90}Sr		^{60}Co		$^{103-106}\text{Ru}$		$^{95}\text{Zr} + ^{95}\text{Nb}$	
	1965	1966	1965	1966	1965	1966	1965	1966	1965	1966	1965	1966
CRM 42.8	3.4	2.5	2.0	3.6	0.29	0.23	0.17	*	6.0	1.4	0.39	0.09
34.7	5.4	4.0	3.4	4.9	0.25	0.36	0.17	0.11	8.1	3.0	0.25	0.32
31.1	5.8	4.2	3.4	5.5	0.41	0.32	*	0.27	10	3.1	0.26	0.34
24.9	5.0	4.2	2.6	4.7	0.23	0.51	*	0.20	5.6	2.7	0.08	0.27
Average	4.9	3.7	2.9	4.7	0.30	0.36	0.08	0.15	7.5	2.5	0.25	0.26
CRM 21.5	0.62	1.2	0.57	0.58	0.38	0.23	0.23	0.83	0.91	1.1	0.15	0.14
16.3	145	26	2.6	1.2	1.2	0.63	10	8.1	2.1	4.2	*	0.27
14.0	49	43	1.2	1.2	0.41	0.45	6.4	8.6	11	5.1	0.10	0.81
11.0	58	86	1.7	2.3	0.92	0.51	8.4	14	9.9	9.2	0.10	0.68
8.0	95	90	2.1	2.3	0.70	0.36	12	19	22	14	0.16	0.86
5.8	114	95	2.8	2.3	0.81	0.96	15	18	28	13	*	0.82
4.7	96	83	3.1	2.3	0.79	0.68	14	16	25	13	0.26	0.68
1.1	78	56	2.8	2.3	0.79	0.54	13	9.9	23	10	0.20	0.41
Average	79	60	2.1	1.8	0.74	0.55	9.9	12	15	8.8	0.12	0.58
TRM 570.8	3.1	2.2	2.2	2.3	0.56	0.41	*	0.14	4.8	2.7	0.20	0.14
562.7	20	15	2.2	2.3	0.32	0.38	2.6	1.9	9.2	3.9	0.25	0.27
552.7	23	19	2.0	3.2	1.1	0.55	2.8	2.3	8.3	4.4	0.22	0.41
543.8	16	9.1	1.9	2.3	0.50	0.20	2.4	1.5	8.0	2.9	0.18	0.14
532.0	12	14	1.5	3.2	0.72	0.36	1.9	1.7	6.2	3.4	0.17	0.54
Average	15	12	2.0	2.7	0.65	0.38	1.9	1.5	7.3	3.5	0.20	0.30

*None detected.

Table 9 RADIONUCLIDES IN TENNESSEE RIVER SILT DOWNSTREAM FROM 532.0--1961 and 1966
(Units of 10^{-6} $\mu\text{Ci/g}$ of Dried Silt)

Location	^{137}Cs		^{144}Ce		^{90}Sr		^{60}Co		$^{103-108}\text{Ru}$		$^{95}\text{Zr} + ^{95}\text{Nb}$	
	1961	1966	1961	1966	1961	1966	1961	1966	1961	1966	1961	1966
TRM 491.9	14	9.3	1.8	2.6	0.36	0.27	3.0	1.1	30	4.2	0.72	0.
354.4	4.6	4.7	0.95	3.6	0.36	0.63	1.1	1.3	13	3.0	0.77	1.
280.0	4.6	7.1	1.5	6.4	0.36	0.50	0.90	1.4	16	4.9	0.72	1.
261.3	6.9	8.7	2.4	8.4	0.45	0.72	1.2	1.5	25	7.2	1.1	1.
207.3	2.6	5.5	0.99	5.2	0.23	0.37	0.81	0.33	12	4.6	0.59	0.
24.6	1.2	2.5	0.86	2.6	0.41	0.41	0.41	0.14	4.4	2.3	0.59	0.
Average	5.7	6.3	1.4	4.8	0.36	0.48	1.2	0.96	17	4.3	0.75	0.
Fort Loudoun Background Data												
TRM 615.8	1.2	2.4	0.77	3.5	0.14	0.46	0.36	0.14	1.9	2.4	0.72	0.
604.4	0.99	1.8	0.99	2.8	0.18	0.41	0.32	0.09	2.3	2.2	0.68	0.
Average	1.1	2.1	0.88	3.2	0.16	0.44	0.34	0.12	2.1	2.3	0.70	0.

6.0 PERSONNEL MONITORING

It is the policy of Oak Ridge National Laboratory to monitor the radiation exposure of all persons who enter Laboratory areas where there is a likelihood of radiation exposure. Dose analysis is accomplished mainly through the use of personnel meters, bio-assays, and in vivo counting (whole body counter) techniques.

6.1 Dose Analysis Summary, 1966

6.1.1 External Exposures - No employee received a whole body radiation dose which exceeded the maximum permissible levels recommended by the Federal Radiation Council (FRC). The highest whole body dose received by an employee was about 4.9 rem or 40 percent of the maximum permissible annual dose. The range of doses for persons using ORNL badge-meters is shown in Table 10.

As of December 31, 1966, no employee had a cumulative whole body dose which exceeded the recommended maximum permissible dose as based on the age proration formula $5(N-18)$ (Table 11). Only one employee had an average annual exposure rate that exceeded 5 rem per year of employment (Table 12).

The highest cumulative dose to the skin of the whole body received by an employee during 1966 was about 16 rem or 53 percent of the maximum permissible annual skin dose of 30 rem.

As of December 31, 1966, the highest cumulative dose of whole body radiation received by an employee was approximately 89 rem. This dose was accrued over an employment period of about 23 years and represented an average annual exposure of about 4.0 rem.

The highest cumulative hand exposure recorded during 1966 was about 25 rem or 33 percent of the recommended maximum permissible annual dose to the extremities.

6.1.1.1 External Dose - The average of the ten highest whole body doses of ORNL employees for each of the years 1960 through 1966 are shown in Figure 19. The highest individual dose for each of those years is shown also.

The dose ranges versus the number of employees for each range for the years 1960 through 1966 are shown in Figure 20. Although the total number of employees increased slightly during the six-year period, the number of persons in the higher dose ranges has decreased.

The average annual dose to ORNL employees for the years 1960 through 1966 is the subject of Figure 21. This rather arbitrary quantity is obtained by dividing the sum of all doses for the year by the number of employees involved.

6.1.2 Internal Exposures - During 1966 there were two cases of internal exposure where the deposition of radioactive materials within the body was estimated to have averaged greater than one-half a maximum permissible body burden.⁷ Both of these cases involved inhalation exposures to ^3H and the resulting estimated doses to the whole body were 10.2 rems and 4.2 rems for the calendar year.

Two employees continued to have estimated body burdens of transuranic alpha emitters (mainly ^{239}Pu) of 35 to 40 percent of the recommended maximum permissible value.⁸ Health Physics procedures require that individuals who exceed 30 percent of a maximum permissible body burden be placed on a work assignment where the potential for internal exposure is reduced.

6.2 External Dose Techniques

6.2.1 Film Meters - Film meters are issued to all persons who have access to ORNL facilities in which there is a likelihood of radiation exposures for which monitoring is required. Either an ORNL badge-meter (Figure 22) or a temporary pass-meter (Figure 23) may be used. Badge-meters are assigned to all ORNL employees, and to certain other persons who are authorized to enter ORNL facilities. Temporary pass-meters may be issued in lieu of badge-meters for short-term use.

NIA (nuclear track) film packets are included in all film meters. The NIA films are processed routinely if the badge-meter is assigned to an individual who normally works where there may be exposure to neutrons; otherwise the films would be processed only in the event of a nuclear accident.

Beta-gamma sensitive films from badge-meters issued to full-time employees are processed routinely each calendar quarter (or more frequently if necessary). Films used in other meters are processed as conditions of use may require. Films from meters issued to visitors are processed if there is a likelihood that a radiation exposure was incurred.

High-level radiation dosimetry components of the badge-meters (sulfur, gold, indium, and metaphosphate glass) are for use in the event that doses exceed the capability of the monitoring films.

For each ORNL division which had one or more employees who sustained a dose greater than 1 rem for the year, the number of employees so exposed are displayed in Figure 24. It may be noted that only ten (of 29) divisions had employees with doses greater than 1 rem, only seven had employees with doses greater than 2 rem, and only three had employees with doses greater than 3 rem.

⁷Handbook 60 values are the basis for these determinations.

⁸AEC Manual Chapter 0502 requires an evaluation of the radiation exposure status of an employee when monitoring techniques indicate that a body burden equals or exceeds 50 percent of a maximum permissible limit.

6.2.2 Pocket Meters - Pocket meters (indirect reading, ionization chambers) are made available at all principal points of entry to ORNL premises. A pair of pocket meters is carried for the duration of a work shift by persons who work in an area where the potential for an exposure of 20 mR or more exists during the work shift. Pocket meter pairs are processed each day by health physics technicians and readings of 20 mR or more are reported daily to supervision.

Pocket meters are used for a day-to-day record of integrated exposures and warn if excessive exposures occur.

Figure 25 is a display of the comparison between whole body doses as determined from film meters and the total recorded pocket meter readings for the ten highest whole body cases for the year 1966.

6.2.3 Hand Exposure Meters - Hand exposure meters (Figure 26) are film-loaded finger rings used to measure hand exposure. Hand exposure meters are issued on a weekly basis to persons for use during operations where it is likely that the hand dose is such as to exceed 1 rem during the week. They are issued and collected by Radiation Survey Unit personnel who determine the need for this type of monitoring and arrange for a processing schedule.

6.2.4 Metering Resume - Shown in Table 13 are the quantities of personnel metering devices used and processed during 1966. The number of films processed is less than the number issued, because those which are issued for accident dosimetry only are not processed unless there was a likelihood of exposure.

6.3 Internal Dose Techniques

6.3.1 Bio-Assays - Urine and fecal samples are analyzed for the purpose of making internal dose determinations. The frequency of sampling and the type of radiochemical analysis performed is based upon each specific radioisotope and the exposure potential. Because of the small quantities of radioactive material in most samples, qualitative analyses are not feasible, and only quantitative analyses for predetermined isotopes are performed routinely.

In most cases bio-assay data require interpretation to determine the dose to the person; computer programs are used for evaluation of extensive data on urinary excretion of ^{239}Pu . An estimate of dose is made for all cases in which it appears that one-third of a body burden, averaged over a calendar year, may be exceeded.

6.3.2 Whole Body Counter - The whole body counter (an in vivo gamma spectrometer) may be used for determining internally deposited quantities of most of the gamma ray-emitting substances, and many of the more energetic beta-emitting substances. Thus, it provides a direct method of determining body burdens of those substances.

6.4 Records and Reports

Most records and reports are prepared by electro-data processing (EDP) techniques through the use of high-speed digital computer systems. The IBM 7090, located at the Central Data Processing Facility (CDPF), provides routine weekly, quarterly, and annual reports involving external dose data. (A typical weekly report is shown in Figure 27; a typical quarterly report is shown in Figure 28.) A CDC 1604, operated by the ORNL Math Panel, is used to prepare the weekly pocket meter report (Figure 29) as well as the weekly, quarterly and annual bio-assay reports. (A sample of the Weekly Bio-Assay Sample Status Report is shown in Figure 30.)

An annual report based on preliminary results of analysis by the whole body counter (IVGS) is prepared by the IBM 7090 at CDPF.

A quarterly and an annual report of occupational injuries is processed by the IBM 360 at ORNL.

An individual external dose summary (Figure 31) is prepared annually by up-dating on the IBM 360 at CDPF.

Body burden estimates of ^{239}Pu are prepared in report form (usually quarterly) by use of the IBM 7090 at CDPF.

Permanent files are maintained at Health Physics and Safety Headquarters for each individual who is assigned an ORNL photo-badge-meter. An IBM card cross-indexing system is maintained at the principal monitoring stations for the purpose of expediting meter assignments. These IBM cards are compatible with the various computer programs and provide for the internal audit of all personnel monitoring record data.

Copies of the EDP reports, both temporary and final, are maintained for both the internal and external dose programs. Data used in the EDP program are stored on computer quality magnetic tapes. Data pertinent to the work of the dosimetry groups and information used in the non-EDP reports are maintained in record form by the Dose Data Group.

6.5 Program Developments

During 1966 the computer program for pocket meter readings was modified to decrease the time required for report preparation and distribution.

A new program was initiated for computer preparation of quarterly reports of occupational injury records. These reports are distributed on a divisional basis and contain in coded form the pertinent information for each occurrence.

A procedure was developed for updating individual external dose summaries on an annual basis. Calendar years 1961 - 1965 are presented in the current printed report and the updated information is stored on computer quality magnetic tape.

A program for revising and increasing the utility of bio-assay results from prior years was started. Computer reports for the calendar years 1961, 1964 and 1965 have been prepared.

Table 10 DOSE DATA SUMMARY FOR LABORATORY POPULATION INVOLVING
EXPOSURE TO WHOLE BODY RADIATION - 1966

Group	<u>Number of Rem Doses in Each Range</u>							Total
	0-1	1-2	2-3	3-4	4-5	5-6	6 up	
ORNL Employees	5665	129	34	19	3	0	0	5850
ORNL-Badged Non-Employees	599	0	0	0	0	0	0	599
TOTAL	6264	129	34	19	3	0	0	6449

Table 11 AVERAGE REM PER YEAR SINCE AGE 18 - 1966

	<u>Number of Doses in Each Range</u>				Total
	0-2.5	2.5-5.0	5.0-7.5	7.5 up	
ORNL Employees	5841	9	0	0	5850

Table 12 AVERAGE REM PER YEAR OF EMPLOYMENT AT ORNL - 1966

	<u>Number of Doses in Each Range</u>				Total
	0-2.5	2.5-5.0	5.0-7.5	7.5 up	
ORNL Employees	5822	27	1	0	5850

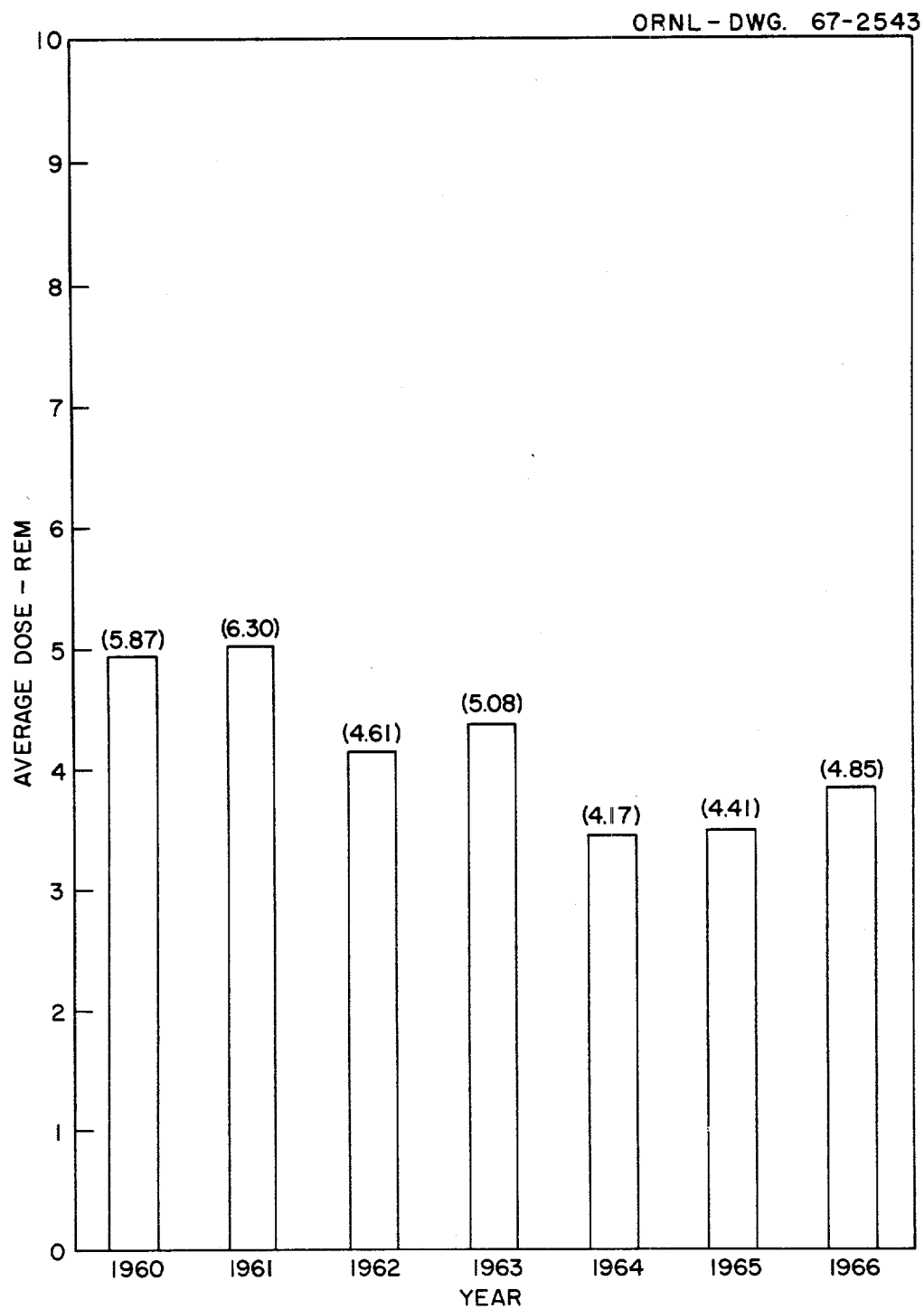


Fig. 19 Average of the Ten Highest Annual Whole Body Doses by Year.
(The Highest Individual Dose Shown in Parentheses)

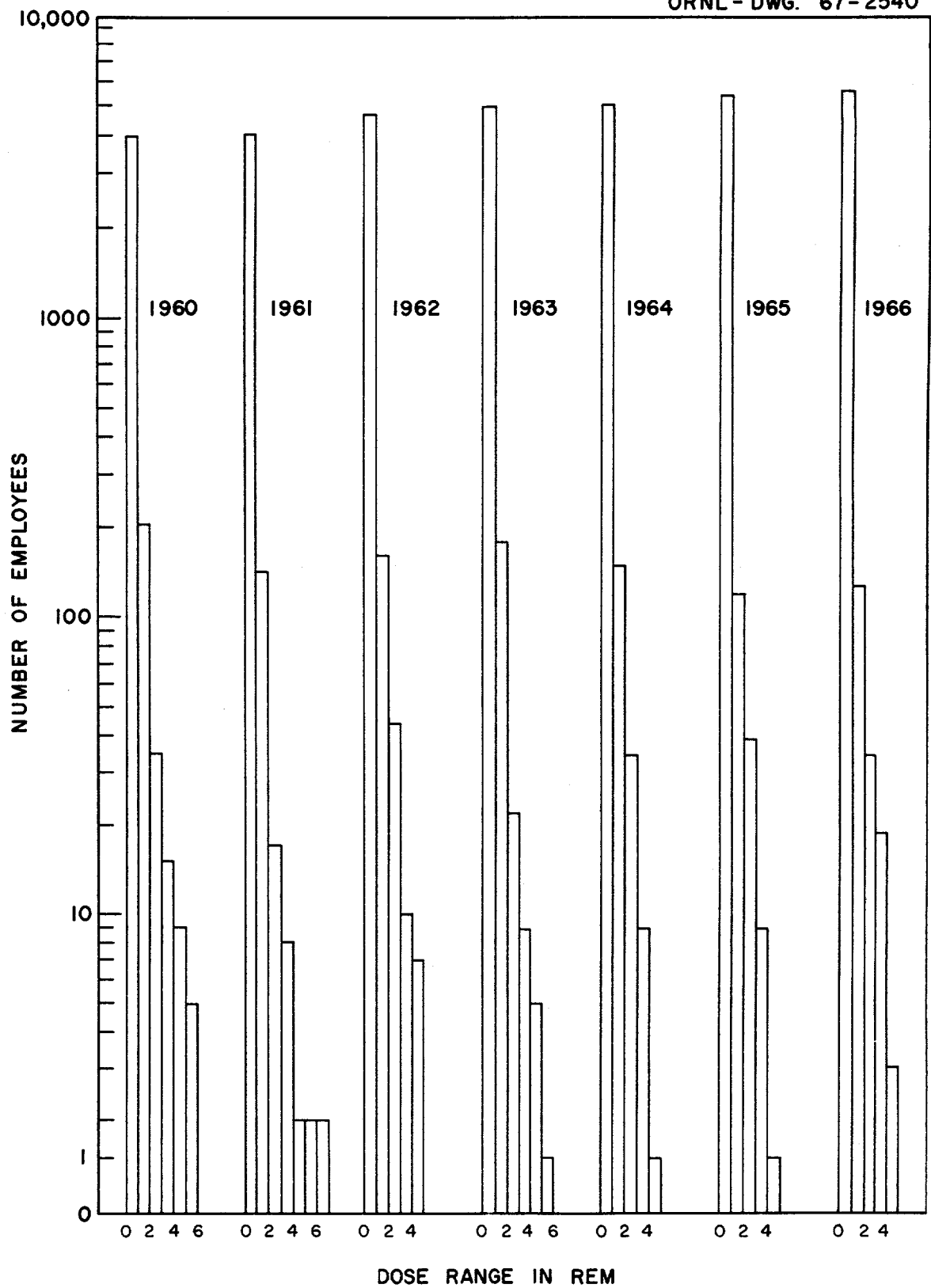


Fig. 20 Whole Body Radiation Dose Range for Employees 1960-1966.

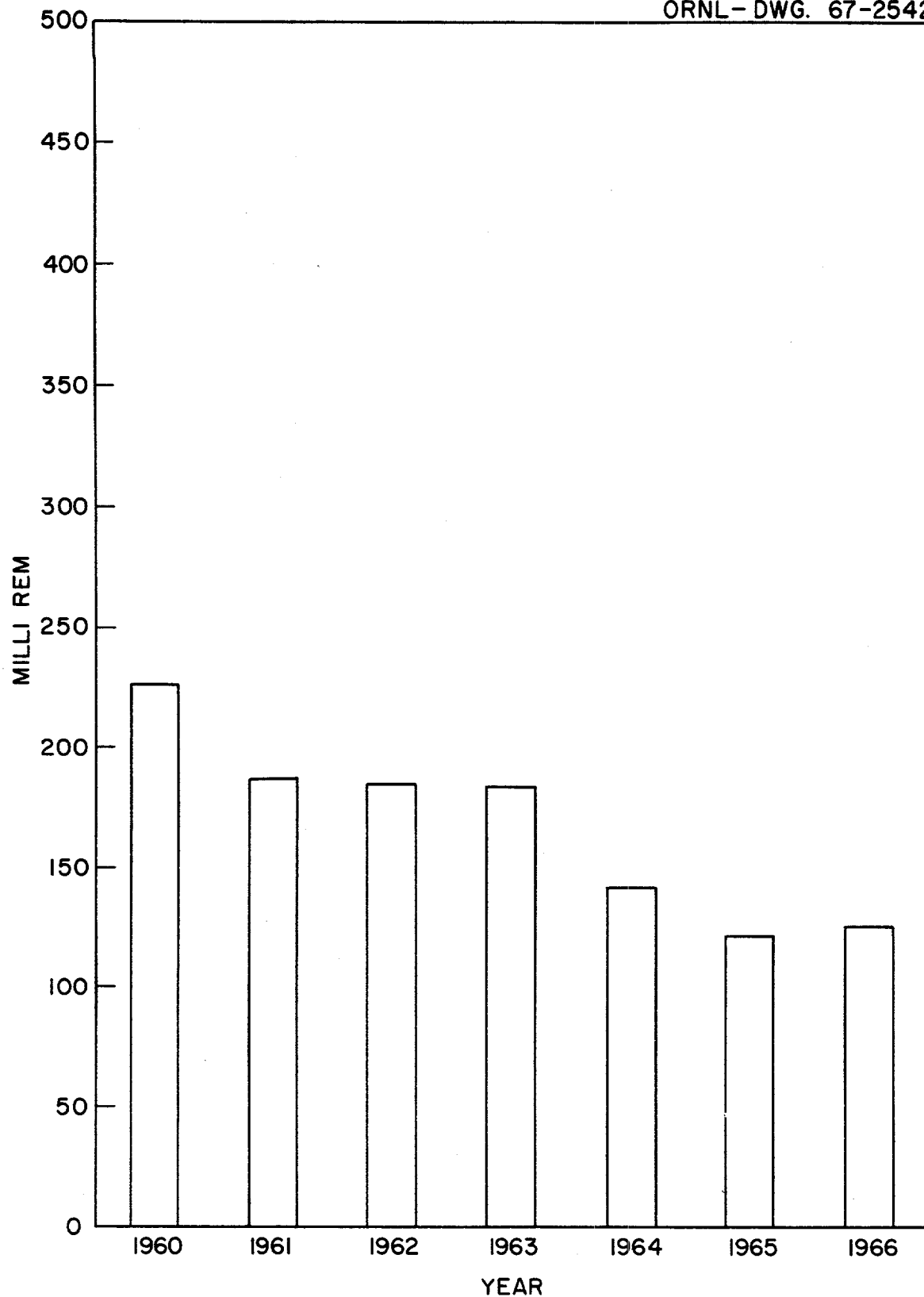


Fig. 21 Average Annual Whole Body Dose to the Average ORNL Employee.

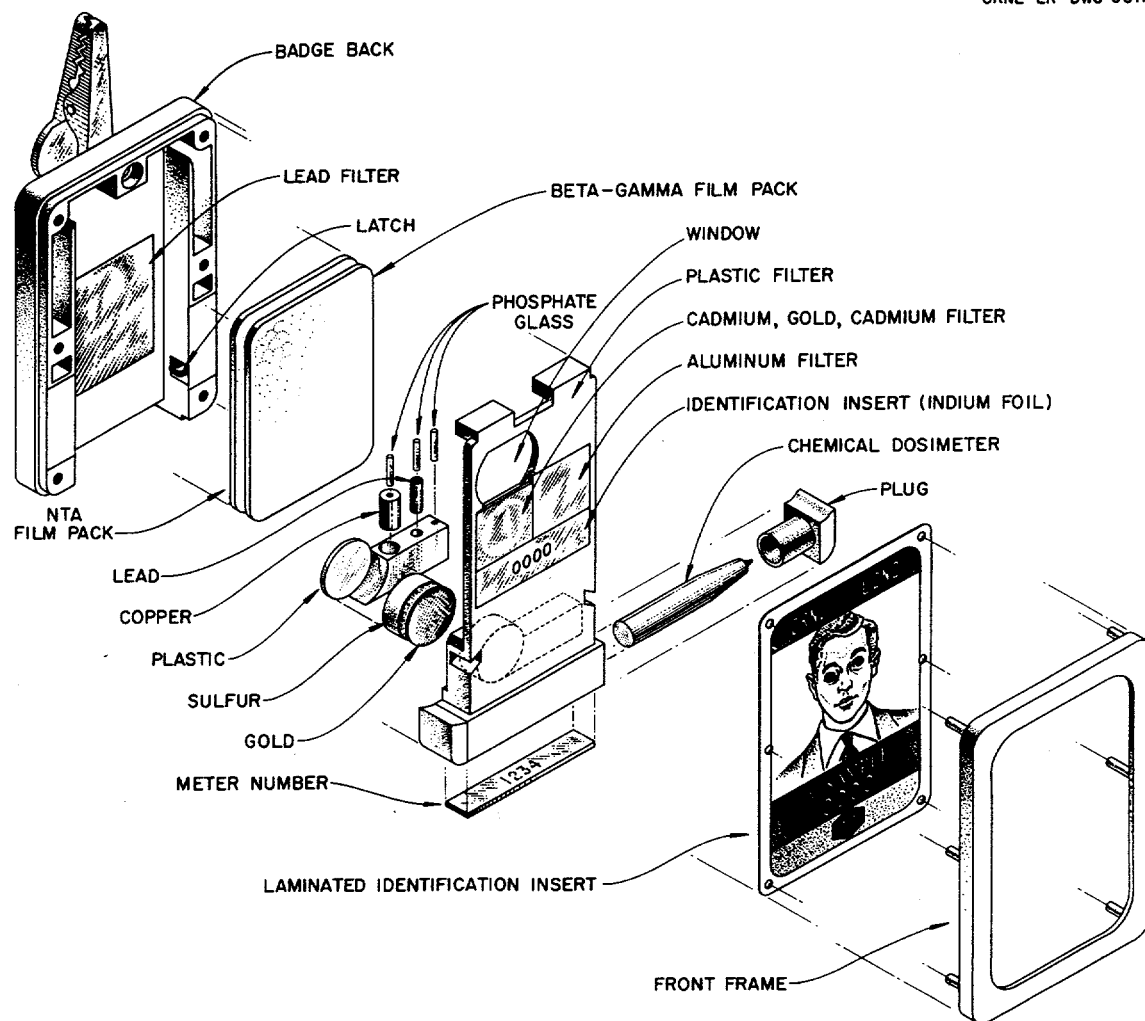


Fig. 22 ORNL Badge-Meter, Model II.



Fig. 23 Typical Temporary Security Passes Equipped with Monitoring Film.

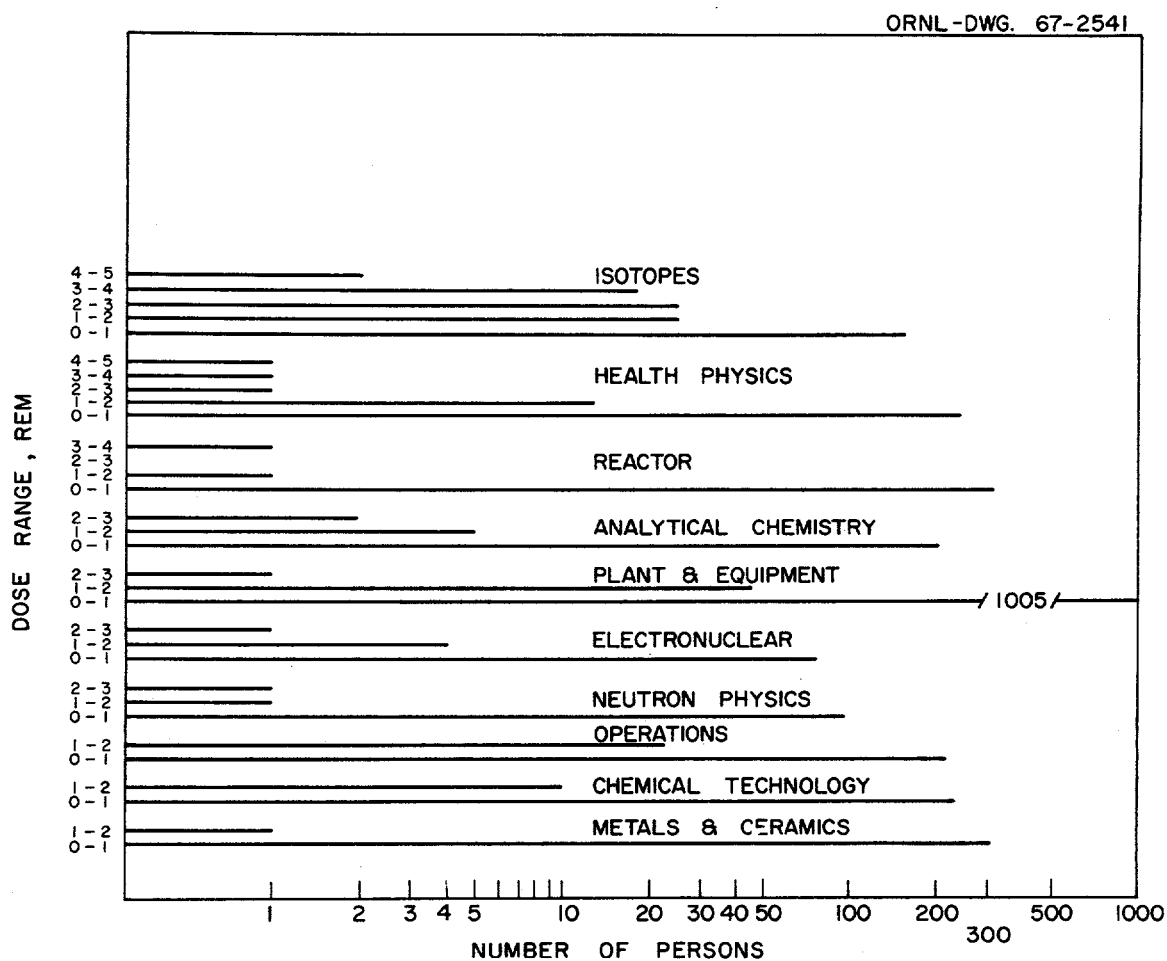


Fig. 24 Personnel Dose (Whole Body) by ORNL Division Having One or More Doses, One Rem or Greater, in 1966.

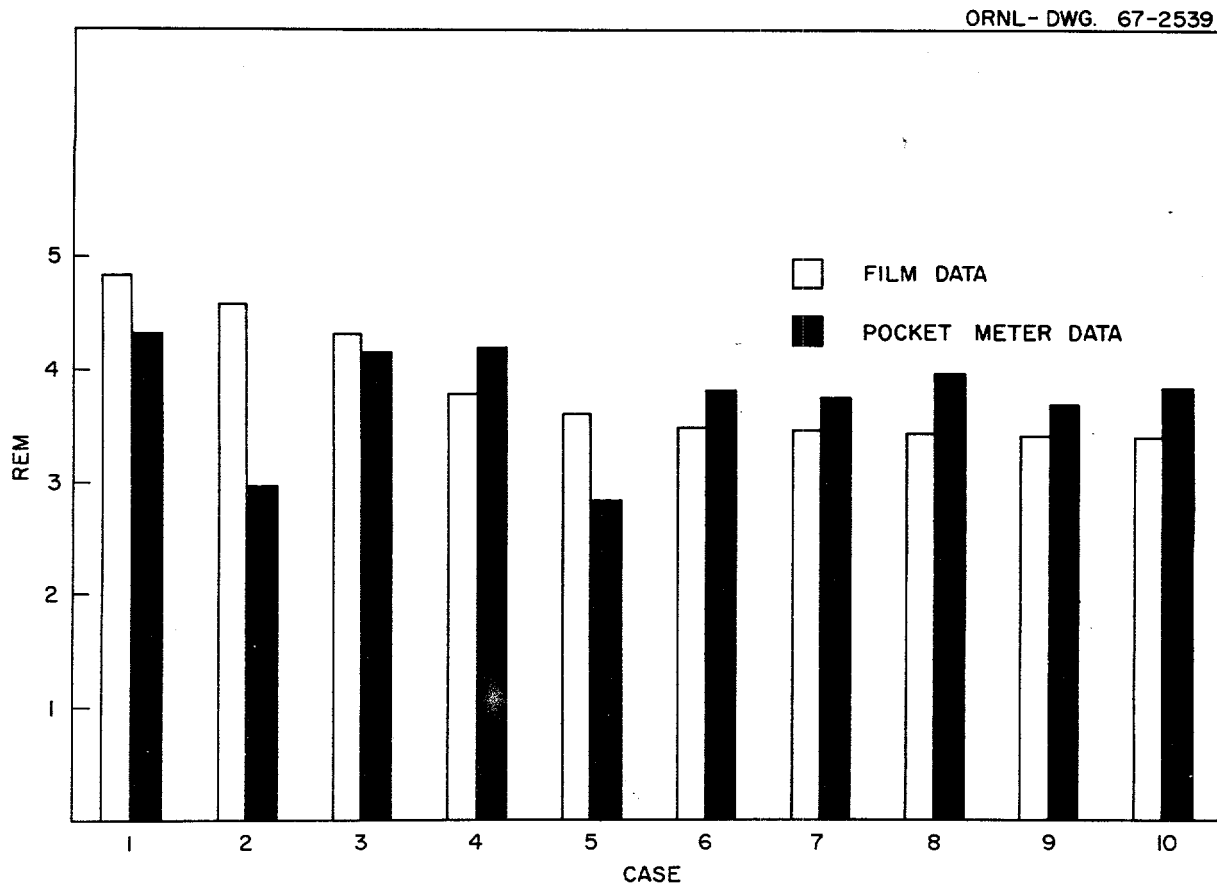


Fig. 25 The Ten Highest Whole Body Radiation Dose Dases Compared with Concurrent Pocket Meter Totals for 1966.

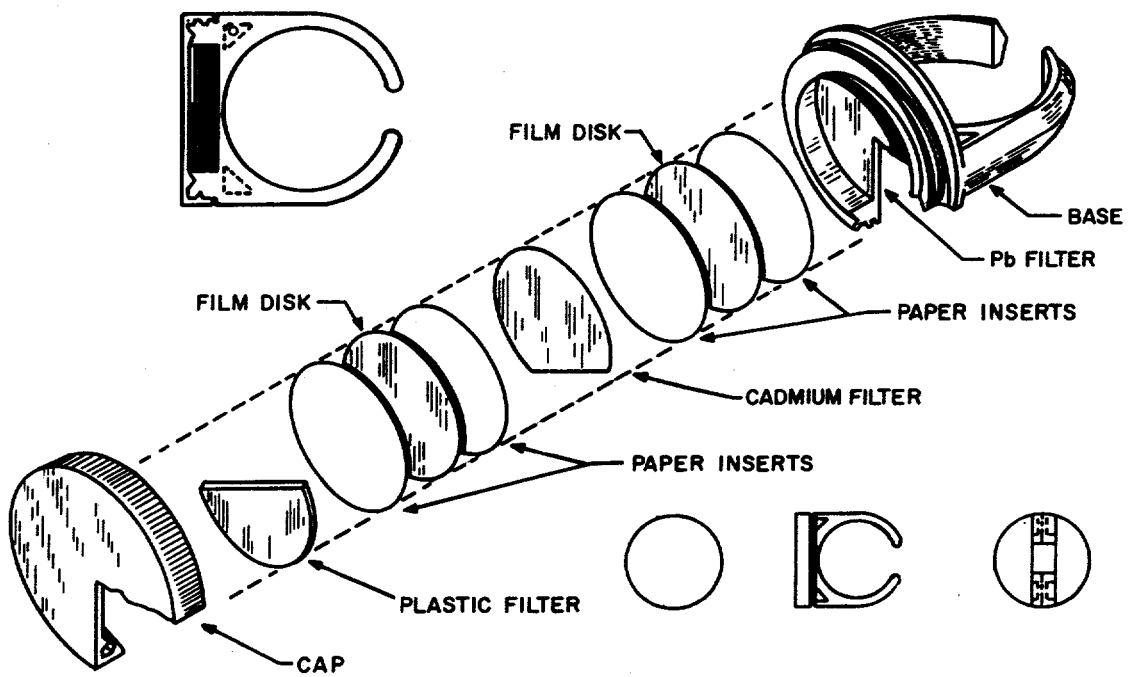


Fig. 26 Details of the ORNL Hand Exposure Meter.

Table 13 PERSONNEL METER SERVICES

	<u>1965</u>	<u>1966</u>
A. Pocket Meter Usage		
1. Number of Pairs Used		
ORNL	140,088	156,676
CPFF	<u>19,656</u>	<u>17,108</u>
Total	159,744	173,784
2. Average Number of Users per Quarter		
ORNL	1,262	1,372
CPFF	<u>256</u>	<u>213</u>
Total	1,518	1,585
B. Film Usage		
1. Films Used in Photo-Badge-Meters		
Beta-Gamma	21,810	21,760
NTA	10,830	10,670
2. Films Used in Temporary Meters		
Beta-Gamma	7,720	7,790
NTA	2,500	2,520
C. Films Processed for Monitoring Data		
1. Beta-Gamma	22,080	22,190
2. NTA	1,690	2,470
3. Hand Meter	1,610	1,940

ORNL DWG. 64-11676

Name	ID Number	Symbol	Dosimetry Dates		Meter Dose	
			Wk-Yr	Qtr-Yr	DS	DC
Last Name, Initials	PR. No.	PF	35-63	3-63	0.000	0.000
Last Name, Initials	PR. No.	PF	31-63	3-63	0.120	0.090
Last Name, Initials	PR. No.	PF	30-63	3-63	0.030	0.000
Last Name, Initials	PR. No.	PF	36-63	3-63	0.070	0.020
Last Name, Initials	PR. No.	PF	34-63	3-63	0.000	0.000
Last Name, Initials	PR. No.	PF	36-63	3-63	0.370	0.310
Last Name, Initials	PR. No.	PF	32-63	3-63	0.000	0.000
Last Name, Initials	PR. No.	PF	33-63	3-63	0.040	0.020
Last Name, Initials	PR. No.	PF	34-63	3-63	0.260	0.130
Last Name, Initials	PR. No.	PF	35-63	3-63	0.040	0.010

Fig. 27 Typical ORNL Film Monitoring Data.

HEALTH PHYSICS DIVISION
DEPARTMENT 5195
RADIATION SURVEY

Name	ID Number	Symbol	Date Wk-Yr	REM		REM This Qtr		REM This Yr		Total REM	A	DC/A
				DS	DC	DS	DC	DS	DC	DC		
----	----	PF	39-63	0.860	0.630	0.860	0.630	1.68	1.32	35.59	18	2.02
----	----	PN	39-63	0.000	0.000							
----	----	PF	39-63	0.340	0.240	0.340	0.240	0.34	0.24	0.24	1	0.80
----	----	PF	39-63	0.020	0.010	0.020	0.010	0.02	0.01	5.21	14	0.38
----	----	PF	39-63	0.070	0.040	0.070	0.040	0.30	0.19	18.38	16	1.19
----	----	PF	39-63	0.390	0.310	0.390	0.310	1.40	1.14	2.74	20	0.14
----	----	PF	39-63	0.350	0.150	0.350	0.150	0.77	0.49	9.60	17	0.56
----	----	PEL	27-63	0.010	0.010							
----	----	PF	39-63	0.140	0.110							
----	----	PN	39-63	0.000	0.000	0.150	0.120	0.27	0.24	5.55	6	1.09
----	----	PF	39-63	0.400	0.200	0.400	0.200	0.73	0.45	7.43	12	0.64
----	----	PF	39-63	0.180	0.150	0.180	0.150	0.60	0.49	8.43	7	1.34
----	----	PF	39-63	0.330	0.110	0.360	0.140	0.81	0.34	3.00	13	0.24
----	----	PN	39-63	0.030	0.030							
----	----	PF	39-63	0.180	0.080	0.180	0.080	0.51	0.33	29.82	18	1.68
----	----	PN	39-63	0.000	0.000							
----	----	PF	39-63	0.320	0.270	0.320	0.270	1.14	0.98	22.76	13	1.76
----	----	PN	39-63	0.000	0.000							
----	----	PF	39-63	0.420	0.290	0.420	0.290	1.85	1.11	15.86	16	1.04
----	----	PF	39-63	0.320	0.140	0.320	0.140	0.67	0.46	8.96	11	0.84
----	----	PF	39-63	0.390	0.210	0.390	0.210	1.21	0.72	33.62	18	1.87

Fig. 28 Typical ORNL Personnel Radiation Exposure Record.

ORNL DWG. 66-4519

DEPT XXXX		HP WK 52												
NAME	PR NO	DC	S	M	T	W	T	F	S	WK	QTR	F	SMB	
-----	----			0	5	10	0			15	270	62		
-----	----	660		10	25		120			155	1140	57	DWQ	
-----	----										35	11		
-----	----										10	1		
-----	----			10	10	0	10			30	220	41		
-----	----			10						10	115	62		
-----	----										5	20		
-----	----		0	10	10		20			40	560	54	D Q	
-----	----										195	22		
-----	----											1		
-----	----		125	0		0				125	260	60	DW	
-----	----			30	0	5	0			35	415	61	D	
-----	----													
ENTRIES													Q COUNT	
23													2	
+													12	
D														
5														
W														
2														

Fig. 29 Typical Pocket Meter Weekly Report.

RESULTS THIS REPORT 12-20-65

Div. Code	Name	PR NO	HP AREA Number	Type Analysis	Receipt Date	Type Sample	Sample Priority	d/m/Sample	d/m/24 hrs
HP	-----	----	3550	GAO	12-16-65	U	3		0
HP	-----	----	3019	PUO	12-12-65	U	3		0
HP	-----	----	3019	PUO	12-16-65	U	3		0
HP	-----	----	3019	SRO	12-12-65	U	3		0
Div. Total 4									

Fig. 30 Typical Weekly Bio-Assay Sample Status Report.

Name - Employee AN

I.D. Number 5782
 S.S. Number 221-16-0038
 Birth Date 6/17/28
 Activation Date 1/16/48

Symbol	Definition
DC	Cumulative recorded total rem to whole body since activation date.
DO	Dose data other than that reported herein Yes (3)

Year	QTR	Rem for Qtr Skin Body	Rem for Year Skin Body	Rem DC
			DC Prior to 1961	22.13
1961	1	.26 .19		
	2	.20 .16		
	3	.29 .12		
	4	.44 .36		
Total			1.30 .83	22.96
1962	1	.33 .30		
	2*	.56 .48		
	3*	.69 .54		
	4	.59 .51		
Total			2.17 1.83	24.79
1963	1	.61 .50		
	2	.53 .43		
	3	.78 .43		
	4	.03 .03		
Total			1.95 1.39	26.18
1964	1	.04 .03		
	2	.02 .01		
	3	.02 .01		
	4	.09 .04		
Total			.17 .09	26.27
1965	1	.25 .12		
	2	.40 .22		
	3	.48 .28		
	4	.41 .21		
Total			1.54 .83	27.10

*See last page for termination and/or reinstatement dates.

Fig. 31 Typical Individual External Dose Summary.

7.0 LABORATORY OPERATIONS MONITORING

Radiation incidents are classified according to a severity index system developed over the past several years.⁹ The method serves to index unusual occurrences according to degree of severity and permits a system of analysis regarding Health Physics and Safety practices among Laboratory operations. This report summarizes the unusual occurrence frequency rate and discusses some of the problems encountered among Laboratory facilities.

7.1 Unusual Occurrences

During 1966 there were 22 unusual occurrences recorded which represents an approximate decrease of 46 percent from the number reported for 1965 (see Table 14) and approximately 42 percent below the five-year average of 38 for the years 1962 through 1966. Four of the occurrences recorded during 1966 involved work with the transuranic isotopes ^{242}Cm , ^{244}Cm , compared with thirteen occurrences involving handling of these isotopes during 1965. This figure represents a significant decrease and indicates improvement in handling and containment of these high specific activity materials. However, as more of the transuranic materials become available for research work the potential for incidents involving these isotopes will also increase.

During 1966 there were no overexposure cases reported, and in only eight cases were minor work restrictions imposed. There were only two cases reported where inter-departmental assistance was required in order to decontaminate facilities for resumption of normal activities. The frequency rate of unusual occurrences among the Laboratory divisions involved (Table 15) are known to vary in relationship to the quantity of radioactive materials handled, the number of radiation workers involved, and the radiation hazard potential associated with a particular operation or facility.

7.2 Radiation Surveys

During 1966 Radiation Survey personnel assisted the operating groups in keeping the contamination, air concentration, and personnel exposure levels well below the established maximum permissible limits. Through seminars, safety meetings and informal discussions with supervision, they assisted in reducing or eliminating a number of problems associated with radiation protection at the Laboratory. The following is a brief description of some of the problems and methods of solution.

7.2.1 Renovation of Bulk Shielding Facility, Bldg. 3010 - Health Physics assistance was given during the renovation of the Bulk Shielding Facility. The reactor's power was increased from one to two megawatts after installation of a forced cooling system. Prior to beginning work on the new cooling system it was necessary to remove most of the contents of the pool, including the Bulk Shielding Reactor and the Pool Critical Assembly. Radiation levels to 55 R/hr were encountered during the transfer of equipment from the pool, but there were no significant exposures

⁹ See Applied Health Physics Annual Report for 1963, ORNL-3665, pp. 14-15.

to personnel. Contamination levels were low, so that only minimal precautions were required. During startup of the renovated facility, Radiation Survey personnel were present to provide a check on the adequacy of the shielding. Radiation levels and air activity were found to be lower with the new facility operating at two megawatts than the previous reactor had been operating at one megawatt. This improvement is due primarily to the characteristics of the forced cooling system.

7.2.2 Renovation of Pilot Plant Cells I, II, III and IV, Bldg. 3019 -
During the year Pilot Plant Cells I, II, III and IV were being readied for installation of future Pilot Plant programs. Process vessels and piping in Cells I and II, highly contaminated with fission products (having surface readings to 10^3 rad/hr), were sampled, shielded, contained and removed to the burial ground. Decontamination is continuing in these two cells. Cell III has been decontaminated to the extent that most of the construction work for the Fluidized Bed Volatility Pilot Plant may be performed without respiratory protection and with only a single suiting of protective clothing. Prior to decontamination, a ^{233}U solution storage tank contaminated to $> 5 \times 10^6$ α d/m was removed to the burial ground. Installation of strategically located bag-out ports in the kilorod cubicles in Cell IV, and the ingenuity of Chemical Technology Division personnel, allowed removal of most process equipment without personnel having to enter the highly alpha contaminated ($> 5 \times 10^6$ α d/m/100 cm^2) cubicles. Final decontamination by personnel in air supplied plastic suits, and application of paint bonds, will enable installation of new process equipment using less restrictive protective apparel and procedures.

Radiation Survey personnel participated in the planning of the above operations and provided on-the-job surveillance. With adequate preplanning and strict adherence to radiation and contamination control procedures the operations were completed with minimal exposure to personnel and dispersion of contamination.

7.2.3 Improvements in the Air Exhaust System for the Analytical Laboratories and HRLAF in Bldg. 3019 - Condensate which periodically drained back from hood exhaust ducts and splattered out of the hoods onto the floor resulted in a contamination problem. Metal troughs, to channel the condensate into a "hot" drain, were installed at the hood outlets to solve this problem.

A routine health physics survey in November of 1965 indicated condensate leaking from the HRLAF exhaust duct because of corrosion of the duct. Temporary repairs were made at that time. Radiation Survey personnel participated in the planning and formulation of procedures for replacement of about 200 feet of the highly contaminated duct in October of 1966. With the cooperation of all involved, and with continuous on-the-job surveillance by Radiation Survey personnel, to assure strict adherence to contamination control procedures, the job was accomplished with minimal spread of contamination and exposure to personnel. The replacement duct has been insulated to reduce condensation of acid vapors.

7.2.4 Renovation and Conversion of Cells, Bldg. 3517 - Cell decontamination and preparation for conversion to new processes in Cells 10, 11, 12, and 13 and the dismantling of Cell 27, Bldg. 3517, were underway throughout the year. The cells were decontaminated from maximum readings as high as 1000 R/hr at one foot from contaminated surfaces to acceptable work levels.

The decontamination and preparation for work to be done by Rust Engineering Corporation was effected without exceeded annual dose limits for ORNL or construction personnel.

7.2.5 Processing ^{242}Cm - Twenty-five thousand curies of ^{242}Cm were processed into pellet form and encapsulated in Cells 1, 2, 3 and 4, Bldg. 3028. This source provided 900 thermal watts, at the time of encapsulation, for testing a 20 watt SNAP-11 generator. This generator was successfully operated (90 days) under simulated lunar conditions in Bldg. 3028-W. Electrical output of the generator was 23 watts under lunar night conditions and 18 watts under lunar day conditions at the start of the test.

The tests were completed during the latter part of the year without the development of any significant problems relating to contamination or exposure to personnel. It is believed that careful planning and rigid control measures that were established played a major role in the success of the program.

7.2.6 Health Physics Assistance During the Disposal of Liquid Waste at Shale Fracturing Site - Continuous monitoring was provided during the disposal of approximately 65,000 gallons of concentrated liquid waste by the Operations Division at the Shale Fracture disposal facility. All personnel exposures were kept below 100 mrem/week during the disposal operation and during maintenance work in the cells prior to the injection operation.

7.2.7 Health Physics and Safety Assistance During Initial Operations of the Transuranic Facility, Bldg. 7920 - Radiation Survey personnel assisted in the final phases of equipment installation and check-out and in the preparation of final operating procedures for the TRU Facility. Following the midyear start-up, with the introduction of radioactive materials into the processing equipment, this assistance was expanded to include specialized and detailed monitoring techniques which are applicable to all stages of process, maintenance, and waste disposal operations related to both the Tramex and Pharex processes, which are for treatment of the higher actinides leading to the isolation and purification of final-product quality ^{252}Cf . There were neither personnel exposures nor unusual occurrences of any significant consequence during the year.

7.2.8 Health Physics and Safety Assistance in Planning Initial Operation of the TRL Facility, Bldg. 5505 - During 1966 the Health Physics and Safety staff of the Transuranium Research Laboratory has made preparations to cope with the specialized safety problems likely to be encountered in the heavy element research program planned for the facility. They have been assigned the responsibility for building operations, with special emphasis

on building containment systems and appropriate training programs. They have assisted the ORNL air-handling group with the testing and balancing of the various ventilation and exhaust systems. They have prepared the initial draft of the Safety Analysis for the TRL, and have initiated and are carrying out a number of radiological and conventional inspection programs to promote the safe operation of the TRL.

7.2.9 Annual Survey of X-Ray Equipment - The annual survey of X-ray producing devices at X-10 and the ORNL portion of the Y-12 operations was completed during July, 1966. The equipment operators and supervision gave full cooperation during the survey. A few X-ray diffraction units were not fully in compliance with the requirement for providing a visible signal to indicate when the X-ray source is energized. These units were promptly changed to comply with the requirements. There are 78 X-ray producing devices currently registered.

7.2.10 Health Physics and Safety Coverage at Operation HENRE - Operation HENRE (High Energy Neutron Reaction Experiment), currently being conducted at the Nevada Test Site, is an experiment to generate and study an intense neutron field produced through $T(d,n)^4He$ reaction. The source of neutrons, a positive ion accelerator which has design features enabling it to transport approximately 400 ma of deuterons to a kilocurie erbium tritide target, creates radiation protection problems common to, but of a much higher magnitude than, those encountered with other neutron generators of the same type. Operation of the accelerator produces neutron fields intense enough to demand absolute exclusion, or shielding, of personnel within several hundred feet of the device. Gross tritium contamination encountered during most maintenance efforts demands the use of protective clothing. With the cooperation of all involved, and under strict Radiation Survey surveillance, the work was accomplished with minimal spread of contamination and exposure to personnel during the 1966 phase of the program.

7.2.11 Health Physics Coverage at Project Salt Vault - Radiation Survey personnel again assisted at the Salt Vault Project in Lyons, Kansas during the placing of 14 irradiated ETR fuel assemblies in the salt mine. Seven assemblies (approximately 1.6 million curies) were placed in the mine in June, 1966 and 7 more (approximately 1.5 million curies) in November, 1966. Although there were high radiation levels in certain areas during some phases of the operation, preplanning, the use of remote operating equipment, continuous monitoring, and strict observance of zoning procedures aided in keeping all personnel exposures well below maximum permissible levels. The maximum exposure received by personnel during the operation was 150 mrem.

7.3 Laundry Monitoring

A total of 780,278 articles of wearing apparel was monitored at the laundry during 1966. This was a decrease of about 21 percent over the number monitored in 1965. Approximately 5.5 percent of the items monitored were found to be contaminated, as compared to about 2 percent last year,

1965. This significant increase in contaminated wearing apparel over the figure for 1965 was due principally to the extensive decontamination work performed in the cells at Bldg. 3517.

Of the 393,243 khaki garments monitored during the year, only 170 were found contaminated. This is a decrease of about 15 percent from last year (1965).

A total of 16,611 full-face respirators were monitored during 1966, and of this number 654 were found to be contaminated. A total of 13,014 filter cannisters for the respirators were monitored, and of this number 391 were found to be contaminated.

Table 14 UNUSUAL OCCURRENCES SUMMARIZED FOR THE 5-YEAR PERIOD ENDING WITH 1966

	1962	1963	1964	1965	1966
Number of Unusual Occurrences Recorded.....	55	43	29	41	22
A. Number of incidents of minor consequence involving personnel exposure below MPE limits and requiring little or no clean-up effort.....	25	11	14	11	8
B. Number of incidents involving personnel exposure above MPE limits and/or resulting in special cleanup effort as the result of contamination.....	30	32	15	30	14
1. Personnel Exposures.....	7	4	9	12	8
a. Nonreportable overexposures with minor work restrictions imposed.....	7	3	9	11	8
b. Reportable overexposures with work restrictions imposed.....	0	1	0	1	0
2. Contamination of Work Area.....	30	32	15	28	14
a. Contamination that could be handled by the regular work staff with no appreciable departmental program loss.....	28	30	14	27	12
b. Required interdepartmental assistance with minor departmental program loss.....	2	2	1	1	2
c. Resulted in halting or temporarily deterring parts of the Laboratory program.....	0	0	0	0	0

Table 15 UNUSUAL OCCURRENCE FREQUENCY RATE WITHIN THE DIVISIONS
FOR THE 5-YEAR PERIOD ENDING WITH 1966

Division	No. of Unusual Occurrences					5-Year Total	Per Cent Lab. Total (5-Year Period)
	1962	1963	1964	1965	1966		
Analytical Chemistry	5	9	3	6	1	24	12.6
Biology	1	2		1		4	2.1
Chemical Technology	13	11	3	8	3	38	20.0
Plant and Equipment	3	1	2	2	2	10	5.2
Inspection Engineering	1		1			2	1.0
Electronuclear Research				1	1	2	1.0
Health Physics		1*	1	2		4	2.1
Instrumentation and Controls			1			1	.5
Isotopes	18	5	12	10	8	53	27.9
Metals and Ceramics	2	1				3	1.6
Neutron Physics	3	2				5	2.6
Operations	6	9*	3	8	4	30	15.7
Physics	2	3	3	2	1	11	5.7
Reactor					2	2	1.0
Reactor Chemistry				1		1	.5
Solid State	1					1	.5
TOTALS	55	43	29	41	22	190	100.0

*Shared responsibility with another division for one unusual occurrence.

8.0 INDUSTRIAL SAFETY

The Laboratory's safety record for 1966, in terms of Disabling Injury Frequency Rate, was very good. The rate was the lowest in the history of the Laboratory and was less than one-third the AEC three-year rate (1963-1965) for all AEC research facilities. First aid and serious injury rates were not comparably reduced during 1966. As approximately one-half of the injuries were to the hands and/or fingers, it is indicated that we must concentrate our effort on this type of injury.

8.1 Accident Analyses

The Disabling Injury Frequency Rate for 1966 was 0.51. The average frequency rate for the previous five years, 1961-1965, was 1.5, and the rate for 1965 was 2.34. The disabling injury history of the Laboratory for the five-year period 1962 through 1966 is shown in Table 16. The disabling injury frequency rates since the inception of Union Carbide as the contractor at ORNL are shown in Figure 32.

There were nine Divisions which did not have a serious or disabling injury during 1966. There are eight Divisions which have accumulated 1,000,000 or more hours since the last disabling injury. The serious injury, disabling injury, and exposure-hour data for ORNL Divisions are shown in Table 17.

Table 18 includes injury data for the four plants—ORNL, Paducah, Y-12 and ORGDP. It is noted that, although the frequency rate for disabling injuries at ORNL is the lowest of the four, the frequency rate for serious injuries at ORNL is second from the lowest. The 93 serious injuries experienced at ORNL were only four less than the 97 experienced in 1965. The frequency rates for disabling injuries and serious injuries for the past five years, 1962-1966, are shown graphically in Figure 33.

There were 1,746 injuries (includes first aid, serious injuries, and disabling injuries) reported during 1966. Figures 34, 35, and 36 show injury data according to type of accident, the nature of the injury, and the part of body injured.

8.2 Analyses of Disabling Injuries

The following is a brief analyses of the four disabling injuries experienced at ORNL during 1966.

Date of Injury - 2/16/66

Employee was walking down aisle where work was being performed on a lead cabinet. The cabinet fell off dolly and caught the employee's left foot causing contusion of great toe.

Date of Injury - 2/16/66

Employee was descending a fixed ladder in a cell. His foot slipped off bottom rung and he fell. Employee's injury diagnosed as severe lumbar strain.

Date of Injury - 9/28/66

Employee was helping to carry a wooden table off a freight elevator. Someone started to close door and employee stumbled and fell, causing extensive lacerations to left little finger.

Date of Injury - 12/17/66

Employee was operating a fire pumper during some hose testing operations. The hose ruptured and a double female connection broke, striking employee in chest. The injury was diagnosed as four ribs fractured and ruptured spleen.

8.3 Safety Award Periods - 1966

November 26, 1965 - February 15, 1966	
1,699,236 hours -	\$2.00
February 17, 1966 - September 27, 1966	
4,793,759 hours -	\$2.00
September 29, 1966 - December 16, 1966	
1,702,407 hours -	\$2.00
	<hr/>
Total Award Value	\$9.00

Table 16. DISABLING INJURY HISTORY

	1962	1963	1964	1965	1966
Number of Injuries	10	11	8	18	4
Labor Hours (Millions)	6.9	7.1	7.5	7.7	7.8
Frequency Rate	1.45	1.55	1.07	2.34	0.51
Days Lost or Charged	2592	1220	1107	2816	231
Severity Rate	377	172	148	366	30

Table 17. INJURY RECORD BY DIVISIONS - 1966

Division	Medical Treatment Cases	Number of Serious Injuries	Disabling Injuries Number Freq. Sev.	Exposure Hours	Exposure Hours Since Last Disabling Injury
Analytical Chemistry	26	1		348,840	4,729,777
Chemical Technology	43	1		455,398	3,387,754
Chemistry	27	2		213,212	293,871
Director's	11			245,212	522,495
Electronuclear	1			106,882	519,514
Health Physics	52	3		411,211	956,928
Instr. & Controls	55			580,370	851,549
Mathematics	6			159,116	1,137,740
Metals & Ceramics	58			545,695	1,594,066
Neutron Physics	6	1		147,104	747,501
Physics	12	2		112,105	2,396,855
Reactor	11			118,025	952,461
Reactor Chemistry	13	1		193,973	1,176,759
Solid State	4			170,160	1,631,357
Gen. Engr. & Constr.	13	1		368,029	946,823
Health	2	1		54,686	819,166
Isotopes	37	8		262,696	366,925
Laboratory Protection	16	2	1 6.95 25	143,782	4,866
Operations	90	2		456,860	515,132
Personnel	28	5		207,199	692,909
Plant & Equipment	1210	63	3 1.38 80	2,173,084	542,208
Technical Information	15			248,107	1,727,948
Inspection Engineering	8			85,570	503,569
PLANT TOTAL	1744	93	4 0.51 27	7,807,316	251,505

Table 18. FOUR-PLANT TABULATION OF INJURIES

	Labor Hours (Millions)	Disabling Number of Injuries	Frequency Rate	Days Lost or Charged	Severity Rate	Serious Number of Injuries (1)	Frequency Rate
ORNL	7.8	4	0.51	210 ⁽²⁾	27 ⁽²⁾	93	11.90
ORGDP	4.7	9	1.92	696	148	40	8.52
Y-12	10.2	8	0.79	2053 ⁽²⁾	202 ⁽²⁾	145	14.27
Paducah	2.0	4	2.02	207	104	25	12.50

(1) Includes the number of disabling injuries.

(2) Estimated.

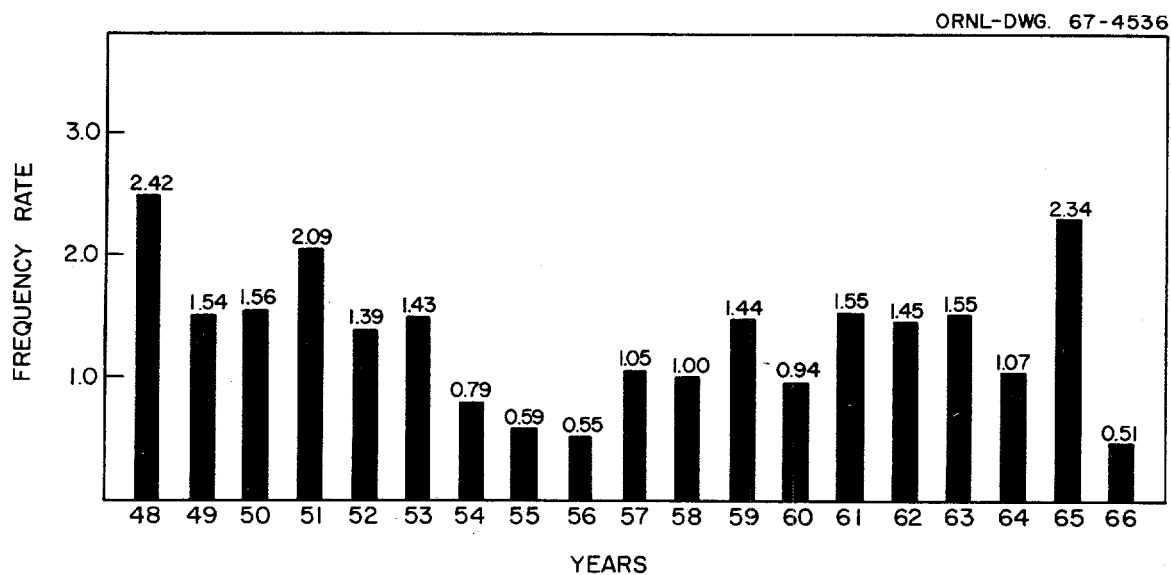


Fig. 32 Disabling Injury Frequency Rates Since Inception of Carbide Contract.

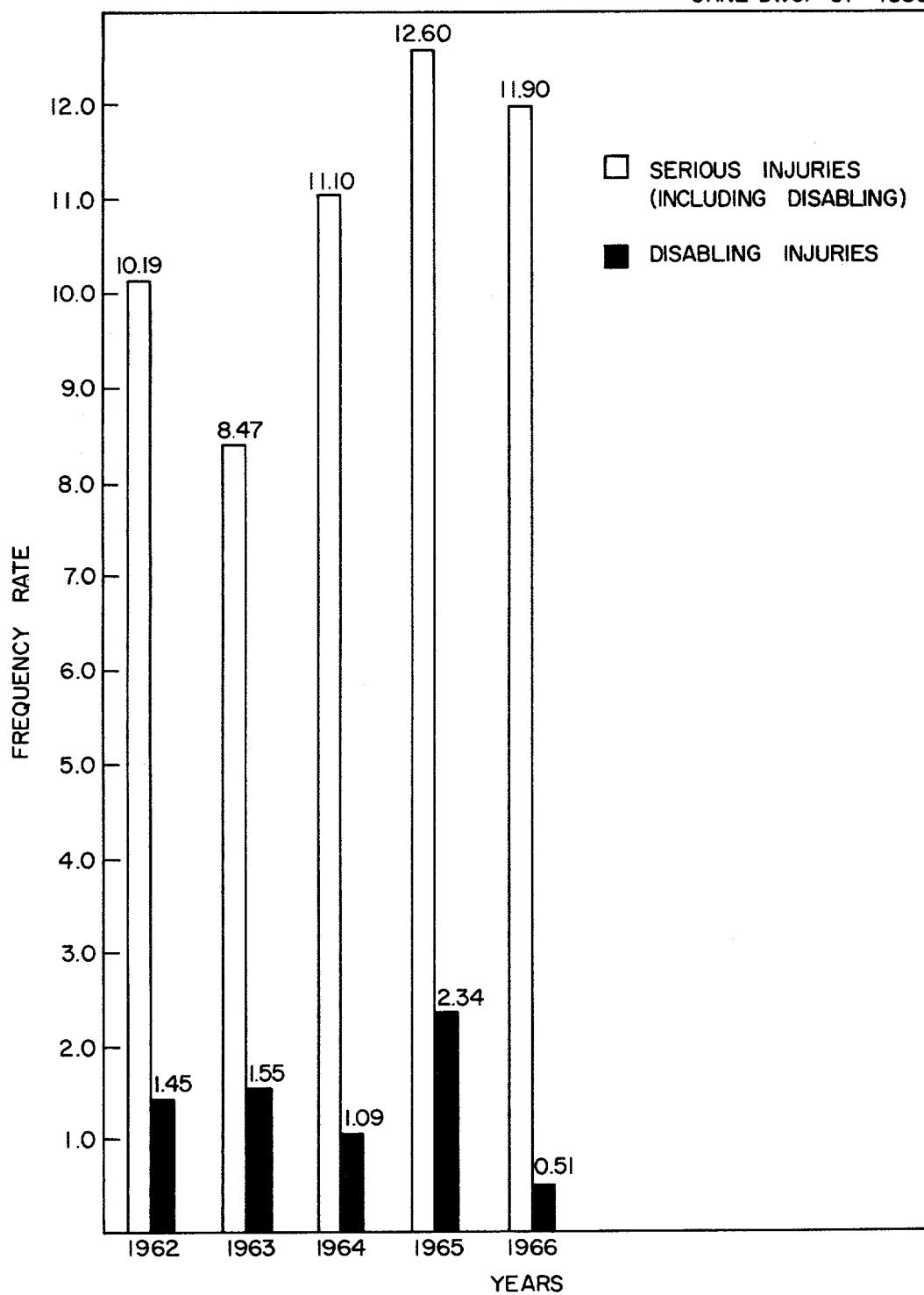


Fig. 33 Injury Frequency Rates - 1962-1966.

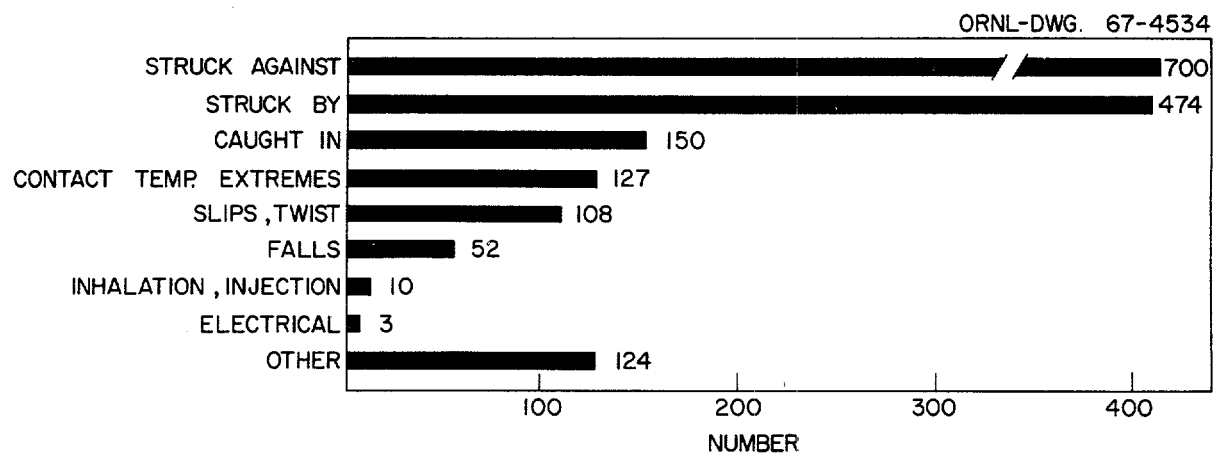


Fig. 34 Accidents by Types.

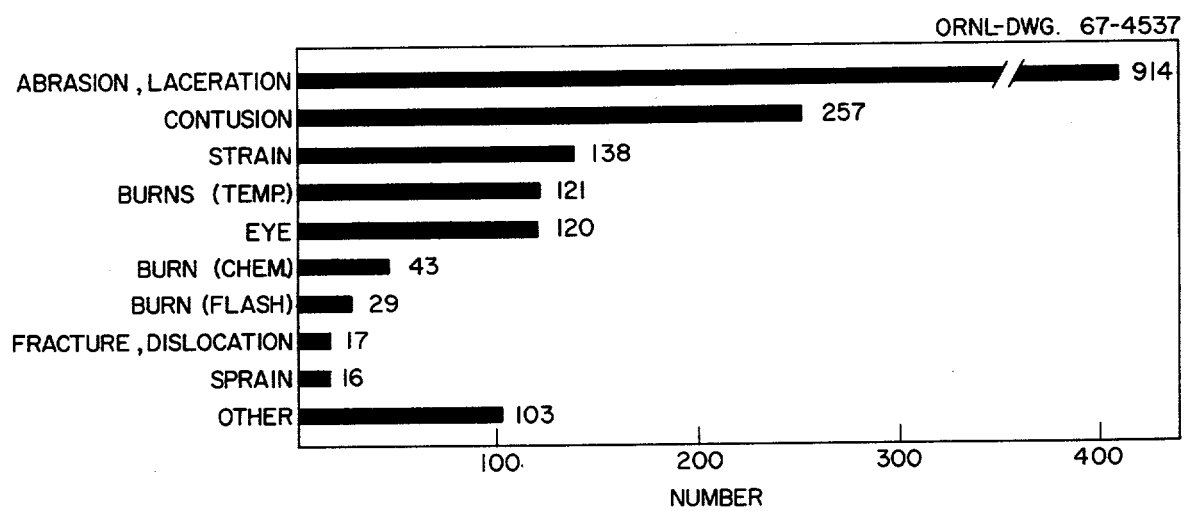


Fig. 35 Nature of Injury.

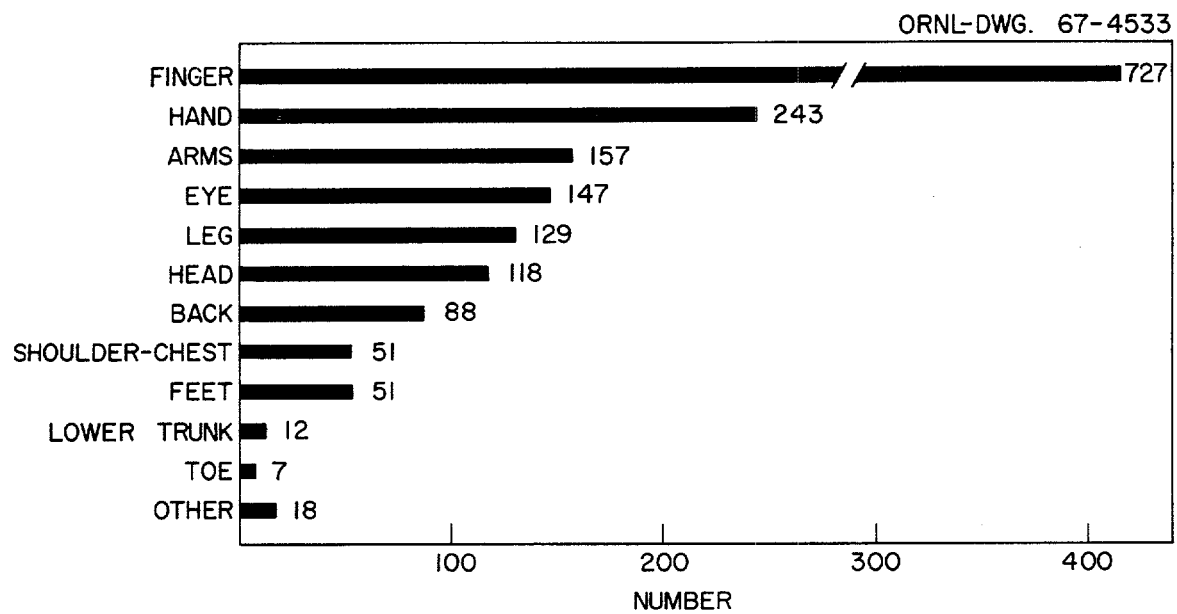


Fig. 36 Part of Body Injured.

9.0 LABORATORY ASSAYS

Laboratory Assays Units provide laboratory support to the Health Physics Monitoring Sections. These services include (1) the analysis of body fluids and excreta (bio-assay) for the monitoring of personnel for internal radiation exposure, (b) the radiochemical analysis of environs samples, (3) counting services for the environs monitoring and radiation survey programs, (4) autoradiography, and (5) whole body counting (in vivo gamma spectrometry).

9.1 Bio-Assay Analysis

The number and types of analyses performed by the Bio-Assay Unit during 1966 are given in Table 19. A total of 5856 analyses were performed which include 5648 analyses on samples submitted by donors and 208 analyses on standard and blank samples analyzed for control purposes. Approximately 85 percent of the samples were analyzed for either the alpha emitters or strontium. The total number of analyses on samples submitted during 1966 decreased by about 25 percent from the number processed during 1965.

9.2 Counting Facility

Over 200,000 samples were processed by the counting facility during 1966. A tabulation of the number and types of samples counted is presented in Table 20. This total represents about a 19 percent decrease in the number of samples processed as compared with the previous year.

9.3 Environs Monitoring Sample Analysis

Table 21 presents the number and type of environs samples analyzed and the type of analysis performed on each type of sample. A total of 8935 samples was analyzed during 1966 as compared with 10,760 samples analyzed in 1965. Analysis of environs monitoring samples may range from a single determination to as many as twelve determinations per sample depending upon the radionuclides present. The methods used by the various analytical groups are generally described in the ORNL Master Analytical Manual.

9.4 Autoradiography

There were 2,116 films processed during 1966 in support of radioparticulate studies conducted by the Environs Monitoring Units.¹⁰

9.5 Whole Body Counter¹¹

During the calendar year 1966 the whole body counting program included 740 counts on 568 persons; 497 or about 67 percent of the counts showed

¹⁰ Methods described in ORNL-2601, "Radioactive Waste Management at Oak Ridge National Laboratory".

¹¹ The Whole Body Counter is operated by the Health Physics Technology Section.

normal human spectra. Of the 740 counts, 41 were initial counts made on persons involved in possible contamination incidents. Only 26 of the 41 showed any indication of internal contamination. There were 122 counts made for the purpose of further investigation of positive counts; 111 of the follow-up counts indicated contamination still present.

In addition to the whole body counts noted above, 40 counts were made to try to pinpoint the location of the contaminant or to determine the amount of contaminant deposited in a given organ or wound site. Also, in addition to the human counts, 63 counts were made for calibration or standard counts and 92 counts were made for the purposes of developing and improving in vivo counting capabilities.

There was no case, based on data collected by the IVGS, for which the AEC reportable level for occupational workers (one-half of a permissible body burden averaged over the year) was exceeded.

Table 19 BIO-ASSAYS ANALYSES—1966

<u>Analytical Procedure</u>	<u>Number of Analyses</u>	
Urine:		
Trans Pu	467	
Sr	1,871	
U	998	
TRE (total rare earths)	-	
³ H	524	
¹³⁷ Cs	182	
²³⁹ Pu	1,429	
¹⁰⁶ Ru	15	
³² P	-	
Other	100	
Total		5,586
Fecal:		
Gross Alpha	3	
Sr	17	
U	-	
Others	42	
Total		62
Miscellaneous:		
Blood, sputum, breath		-
Standards and blanks		208
GRAND TOTAL		5,856

Table 20 COUNTING FACILITY RESUME --1966

Types of Samples	Number of Samples			Unit Total	Weekly Average
	Alpha	Beta	Gamma		
Survey Area Samples					
Smears	80,472	81,476		161,948	3,114.4
Air Filters	22,005	22,099		44,104	848.2
Enviorns Monitoring					
Air Filters	2,001	2,001		4,002	77.0
Gummed Paper		1,550		1,550	29.8
Rain Water		1,604		1,604	30.8
White Oak Lake Effluent	203	1,083		1,286	24.7
Animal Thyroids			265	265	5.1
Milk			445	445	8.6
GRAND TOTAL	104,681	109,813	710	215,204	4,138.5

Table 21 ENVIRONMENTAL MONITORING SAMPLES—1966

<u>Sample Type</u>	<u>Type of Analysis</u>	<u>Number Samples</u>
1. Monitoring network filters	Gross beta, autoradiogram	1,806
2. Gummed paper fall-out trays	Gross beta, autoradiogram	1,450
3. CAM filters	Gross beta, autoradiogram	3,494
4. Rain water	Gross beta	748
5. White Oak Dam effluent	Gross beta, radiochemical, gamma spectrometry	429
6. Clinch River water	Gross beta, radiochemical, gamma spectrometry	20
7. Raw milk	Radiochemical	462
8. Pasture grass	Radiochemical, gamma spectrometry	224
9. Potable water	Radiochemical, gamma spectrometry	12
10. Silt composites	Radiochemical, gamma spectrometry	25
11. Animal thyroids	Gamma spectrometry	265
TOTAL		8,935

10.0 HEALTH PHYSICS INSTRUMENTATION

The Health Physics Division shares with the Instrumentation and Controls Division the responsibility for the development of electronic radiation monitoring instruments used in the Laboratory health physics program. Normally the Health Physics Division is responsible for determining the need for new instrument types and modifications to existing types, specifies the health physics requirements for design, and approves the final design. The Health Physics Division is also responsible for calibrating all instruments used in the health physics program and is allocated the funds for maintenance of these instruments. Maintenance is performed or cross-ordered by the Instrumentation and Controls Division.

Non-electronic personnel monitoring devices are designed, tested, calibrated, and maintained by Health Physics Division personnel.

10.1 Instrument Inventory

The electronic instruments used in the health physics program are divided, for convenience in servicing and calibrating, into two classes: the first class includes battery-powered portable instruments; the second class includes the stationary instruments that are ac powered. Portable instruments are assigned and issued to the Radiation Survey Units. Stationary instruments are the property of the Laboratory Division which has the monitoring responsibility in the area in which the instrument is located. Table 22 lists portable instruments assigned at the end of 1966; Table 23 lists stationary instruments in use at the end of 1966. There were net increases in 1966 of 77 portable instruments and 44 stationary instruments.

During 1966, 1214 new pocket meters, 842 new fiber dosimeters (200 mR range) and 154 personal radiation monitors (PRM) were issued by ORNL Stores. Most of the pocket meters issued were replacements for instruments which had been lost or damaged.

Inventory and Service Summaries for health physics instruments are prepared on a CDC 1604. These computer programmed reports enable the Instruments Group to maintain a current inventory on most health physics instrument requirements.

The allocation of stationary health physics monitoring instruments by Divisions is shown in Table 24.

10.2 Calibration Facility

The Health Physics Division maintains a calibration facility for the calibration and maintenance of portable radiation instruments and personnel metering devices. The facility is equipped with calibration sources, remote control devices, and shop space for the use of Instrumentation and Controls Division maintenance personnel. Health Physics personnel assign, arrange for maintenance of, calibrate, provide delivery services for, and maintain inventory and servicing data of all portable health physics survey instruments.

Portable instruments should be serviced (1) whenever repairs are needed, (2) at least once each two months for those which have replacement-type batteries, and (3) at least once each three months for those instruments which have "permanent" (rechargeable) batteries. The number of calibrations of portable instruments for 1966 is shown in Table 25.

Stationary instruments are calibrated by Calibrations Group personnel or by Radiation Survey personnel who use sources which are designed, standardized, and provided by the Calibrations Group.

10.3 Instrumentation Developments

Experiments were continued to determine the response of field-type radiation survey instruments to beta radiation from small-area sources, in order to evaluate their capability for estimating personnel skin dose exposures. On the basis of the data, an instrument was developed for this purpose and a report (ORNL-TM-1581) was prepared.

A portable, air proportional, alpha survey instrument was prototyped and tested, and approved for use as a health physics instrument.

A transistorized circuit for inclusion in the ORNL Cutie Pie survey instrument was designed and is being evaluated. The power for operation is obtained from two D cells.

The prototype alpha air monitor (Figure 38) was field tested and found to be useful for detecting particulate alpha emitters in the presence of radon-thoron and daughters. A report is being prepared.

Table 22 PORTABLE INSTRUMENT INVENTORY - 1966

Instrument Type	Instruments Added 1966	Instruments Retired 1966	Assigned Inventory Jan. 1, 1967
GM Survey Meter	25	2	435
Cutie Pie	18	8	453
Juno	0	0	32
Alpha Survey Meter	28	2	216
Neutron Survey Meter	18	0	73
Miscellaneous	0	0	14
TOTAL	89	12	1223

Table 23 INVENTORY OF FACILITY RADIATION MONITORING INSTRUMENTS
FOR THE YEAR - 1966

Instrument Type	Installed During 1966	Retired During 1966	Total Jan. 1, 1967
Air Monitor, Alpha	10	2	87
Air Monitor, Beta	6	2	177
Hand-Foot Monitor	3	1	34
Lab Monitor, Alpha	18	1	121
Lab Monitor, Beta	11	1	175
Monitron	4	1	233
Other	5	5	150
TOTAL	57	13	977

Table 24 HEALTH PHYSICS FACILITY MONITORING INSTRUMENTS
DIVISIONAL ALLOCATION - 1966

ORNL Division	α Air Monitor	β Air Monitor	α Lab Monitor	β Lab Monitor	Monitron	Other	Total
Analytical Chemistry	4	12	8	16	15	6	61
Chemical Technology	39	39	44	23	33	29	207
Chemistry	5	9	9	13	19	8	63
Metals and Ceramics	9	16	13	17	11	12	78
Reactor	4	12		9	11	8	44
Isotopes	17	30	20	36	53	25	181
Operations	1	43	2	19	60	17	142
All Others	8	16	25	42	31	79	201
TOTAL	87	177	121	175	233	184	977

Table 25 CALIBRATIONS RESUME - 1966

	<u>1965</u>	<u>1966</u>
A. Portable Instruments Calibrated		
1. Beta-Gamma	4,065	3,792
2. Neutron	142	152
3. Alpha	985	984
4. Pocket Chambers and Dosimeters	2,843	3,224
 B. Films Calibrated		
1. Beta-Gamma	1,700	1,310
2. Neutron	18	20

PHOTO 84267



Fig. 37 Photograph of Prototype Alpha Air Monitor.

11.0 PUBLICATIONS AND PAPERS

H. H. Abee, "Whole-Body Counting—An Environmental Monitoring Tool", Nuclear Safety, Vol. 7, No. 2, pp. 229-231, Winter 1965-1966.

R. J. Pickering, H. H. Abee, et al., "Radioactivity in Bottom Sediment of the Clinch and Tennessee Rivers", Proceedings of Symposium on the Disposal of Radioactive Wastes into Seas, Oceans and Surface Waters, Vienna, Austria, May 16-20, 1966.

T. J. Burnett, "Comparison of Hand Exposure Data with Film Badge", paper presented at the Eleventh Annual Meeting of the Health Physics Society, Houston, Texas, June 27-30, 1966.

D. M. Davis and E. D. Gupton, Health Physics Instrument Manual, ORNL-332, (Special Edition) April, 1966.

E. D. Gupton, "Estimation of Beta Radiation Dose to the Skin by Means of Field Instrument Measurements", paper presented at the Eleventh Annual Meeting of the Health Physics Society, Houston, Texas, June 27-30, 1966.

E. D. Gupton, "Estimation of Beta Radiation Dose to the Skin by Means of Field Instrument Measurements", ORNL-TM-1581, July 29, 1966.

E. D. Gupton and D. M. Davis, "Health Physics Instruments", Chapter 15 of Principles of Radiation Protection, Edited by K. Z. Morgan and J. E. Turner, to be published by John Wiley and Sons, Inc.

E. D. Gupton, "Photographic Film Dosimeters", Chapter 2; "Calibration Techniques", Chapter 8; and "Personnel Monitoring Records", Chapter 9 of Personnel Dosimetry Systems for External Radiation Exposures, IAEA Safety Series, Edited by S. Somasundaram, to be published in 1967.

J. C. Hart, "On the Legalistic Aspects of the Radiation Exposure Record", paper presented at the Eleventh Annual Meeting of the Health Physics Society, Houston, Texas, June 27-30, 1966.

J. C. Hart, "Development and Growth of the Health Physics Profession", paper presented to the membership of the Western Pennsylvania Chapter of the Health Physics Society, Pittsburgh, Pennsylvania, October 3, 1966.

L. C. Henley, "Urinalysis by Ion Exchange", Proceedings of the 11th Annual Bio-Assay and Analytical Chemistry Meeting held at Albuquerque, New Mexico, October 7-8, 1965, CONF-651008, 1966.

A. D. Warden, "Regulations for the Safe Transport of Radioactive Materials, 1964 Revised, IAEA, Vienna, 1964, 104 pp", Book Review published in Health Physics, Vol. 12, No. 4, April 1966.

12.0 VISITORS AND TRAINING GROUPS

During 1966 there were 74 visitors to Health Physics and Safety, as individuals or in groups, for training purposes. Table 26 is a listing of the training groups which consisted of eight or more persons.

Table 26 TRAINING GROUPS IN HEALTH PHYSICS AND SAFETY
FACILITIES DURING 1966

Facility	Number	Training Period
U. of North Carolina (Public Health)	9	9/6/66 - 9/9/66
U. of Arkansas (Radiological Health)	8	4/20/66 - 4/21/66
AEC Fellowship	16	6/13/66 - 8/26/66
ORINS 10-Weeks Course	20	10/31/66 - 11/4/66

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| 72. A. D. Callihan | 129. R. A. McNees |
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| 74. R. L. Clark | 131. E. C. Miller |
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| 76. J. A. Cox | 135. M. L. Nelson |
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